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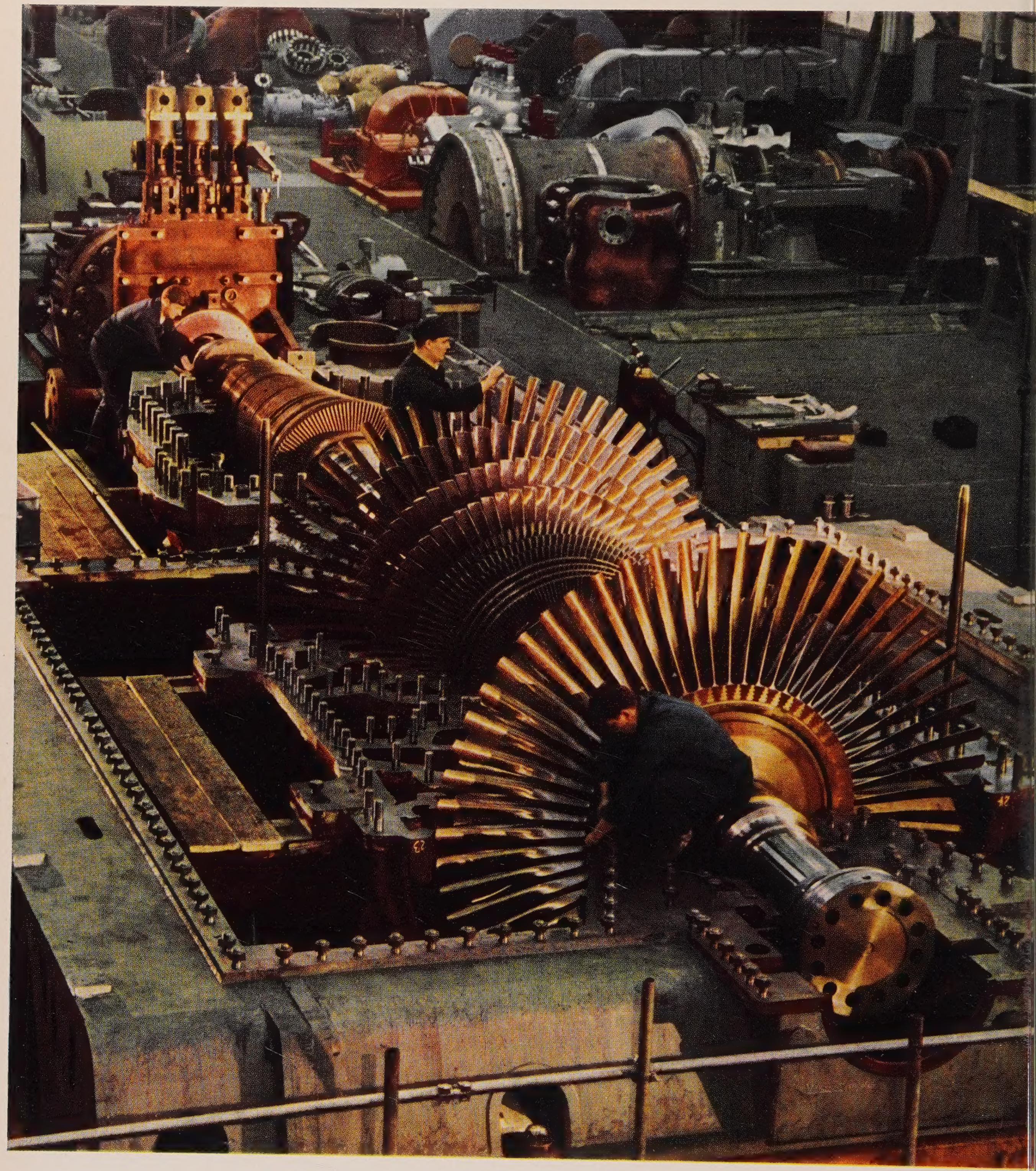

160-MW, 3,000-r.p.m. three-cylinder condensing turbine in the test bay at the works in Mülheim. The low-pressure blades in the last row are 750 mm (2′-5 1/2″) long

SIEMENS

REVIEW

SIEMENS & HALSKE AKTIENGESELLSCHAFT · SIEMENS-SCHUCKERTWERKE AKTIENGESELLSCHAFT

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Direct Inward Dialing to PABX Extensions — A Dial Office Problem?

By Herbert Töpfer and Konrad Rohde

Most telephone subscribers are today able to dial straight through to any other subscriber in the country in a matter of seconds. This state of progress has been achieved through the introduction of nationwide direct distance dialing between interconnected local dial office networks. Direct distance dialing is also steadily being extended across frontiers so that subscribers in different countries can dial straight through to each other without the assistance of a telephone operator.

One link in the chain of direct distance dialing has, however, not yet been fully closed: calls to PABX extensions are answered – the same as 50 and more years ago – by a "telephonist" in a more or less friendly manner and put through to the wanted extensions more or less efficiently. Nowadays telephone users naturally find this question-and-answer routine of the telephonist rather troublesome and the delay before the telephonist answers and while she puts through the call is felt to be not in keeping with modern times. If, on top of this, they are put through to a wrong extension or their instructions are misunderstood, the resulting annoyance is liable to cloud the atmosphere for the coming conversation. If it is further borne in mind that about 70 to 80% of all long-distance calls are directed to PABX extensions and that the charge for the call begins the moment the telephonist answers, the annoyance to telephone users caused by delays and mistakes on the part of the telephonist are readily understandable.

At a time where direct distance dialing is also being extended beyond national frontiers, the answering of calls to PABX extensions by a PABX telephonist is therefore undesirable. A telephonist should here be available only as a helping spirit who may be called upon to render assistance if required.

Telephone switching technology here offers the solution of direct inward dialing to PABX extensions as a natural development in line with progressive automation.

Direct inward dialing to PABX extensions has been allowed in Germany for some 35 years [1]. Since 1950 Siemens & Halske have supplied or modified PABX's with some 100,000 extensions for direct inward dialing. The proprietors of PABX's so adapted can have as many trunk-access extensions as they desire and are free to number them as they please. Above all, no restrictions exist with regard to the length of the call numbers assigned to such extensions.

The same freedom of choice is not conceded to the proprietors of PABX's with direct inward dialing in other countries, where extension numbers or at least the length of extension numbers are fixed by the PTT.

In the public telephone systems of the future, direct inward dialing to PABX extensions will play an important role. As empirical experience shows that all cutovers from manual to automatic switching result in considerably shortened holding times, direct inward dialing will permit the traffic-handling capacity of public telephone networks to be effectively enhanced. The problems here liable to arise should therefore be given due study.

The primary factors of interest in this connection are – as already indicated – the method of numbering to be used for PABX's and PABX extensions adapted for direct inward dialing, and the relation between such numbering and the numbering plan of the dial office network. The registration of call charges run up on long-distance calls dialed by PABX extensions is likewise an important factor, but admits of various solutions.

In the present paper we shall attempt to treat both numbering problems in a general manner; in conclusion an account will be given of experience already made with German PABX's adapted for direct inward dialing.

Numbering of PABX extensions adapted for direct inward dialing

When PABX's are adapted for direct inward dialing, outside telephone users have a greater quantity of call numbers to choose from by dialing. Prior to this, a PABX could only be reached under a single call number; now any trunk-access PABX extension can be dialed as well. This means that the dial office network must be able to handle either more or longer call numbers.

A similar situation arises when full-automatic international long-distance dialing is introduced. It is here the telephone subscribers in the other country who appear as new numbers that can be directly dialed; prior to this, telephone subscribers desiring to make an international call could not dial further than their local long-distance switchboard.

Numbers required for PABX extensions adapted for direct inward dialing

The quantity of numbers that can be dialed in addition to normal directory numbers following the general introduction of direct inward dialing can be estimated from known statistics. Table 1 shows the ratio of the quantity of PABX extensions to the quantity of single-trunk directory numbers in various countries. Ratios range between 20 and 90%; it is seen that in some countries there are almost as many PABX extensions as there are single-trunk telephone installations.

Direct inward dialing will be of interest primarily for PABX's with 10 or more extensions; in West Germany, for example, about two thirds of the installed PABX's are of this category. Taking this as a guiding figure, PABX extensions equivalent to about 15 to 60% of all single-trunk directory numbers must be regarded as potential targets of direct inward dialing.

PABX's with ten or more extensions are found for the most part in large cities. German statistics show that the ratio of PABX extensions to single-trunk telephone installations in large cities averages the same as for the entire country (approx. 90%). Table 2 shows the figures for ten large German cities to range from 57 to 117%.

It may be assumed that conditions are more or less similar in the USA, England, France, Switzerland, the Netherlands and in other countries where the percentage of PABX's is high. In countries with only a relatively small number of PABX's it is perhaps more correct to assume the percentage to be somewhat higher in large cities than for the country as a whole.

The statistics thus indicate that the introduction of direct inward dialing to PABX extensions demands that the latter be allocated a quite considerable quantity of new call numbers. At least up to 50% and, in many cases, even up to 100% more call numbers will be required than before. As a result, the method of allocating call numbers to PABX's adapted for direct inward dialing and to their trunk-access extensions becomes a matter of critical budgetary importance.

Country	Telephones (total)	PABX extensions N	Single-trunk subscribers H	N/H in %
USA	66645000	20659950	45985050	45
England	7524789	2884252	4640537	62
West Germany	5090102	2398837	2691265	89
Japan	4334602	1431792	2902810	49
France	3703578	1696054	2007524	85
Italy	3182455	669133	2513322	27
Sweden	2526424	514127	2012297	26
Australia	1998704	547245	1451459	38
Spain	1490151	415603	1074548	39
Switzerland	1475003	506867	968136	52
Netherlands	1402155	491410	910745	54
Argentina	1223509	341783	881726	39
Belgium	1036305	315564	720741	44
Denmark	978667	209630	769037	27
Norway	672406	214161	458245	47
Austria	615328	245702	369626	67
Finland	545338	153836	391502	39
Jugoslavia	217542	99374	118168	84
Greece	168993	29704	139289	21
Luxembourg	42411	13005	29406	44

Table 1 Single-trunk subscribers and PABX's in various countries (Status on Jan. 1, 1959)

Local network	Telephones (total)	PABX extensions N	Single-trunk subscribers H	N/H in %
Hamburg	366963	153374	213589	72
West-Berlin	307760	111939	195821	57
Munich	195343	85934	109409	79
Frankfort (Main)	164316	87562	76754	114
Düsseldorf	147153	74333	72820	102
Stuttgart	139074	74896	64178	117
Cologne	135175	67583	67592	100
Hanover	112296	56215	56081	100
Bremen	85618	39413	46205	85
Essen	76605	37077	39528	94

Table 2 Single-trunk subscribers and PABX's in ten large German cities (Status on Jan. 1, 1959)

Methods of numbering

The demand for the allocation of call numbers to PABX extensions so as to permit the introduction of direct inward dialing can be satisfied in either of two basic ways. For the sake of clarity we shall refer to one method as "fixed" and to the other as "free" numbering.

With fixed numbering, PABX extensions adapted for direct inward dialing are allocated the same type of

call numbers as ordinary single-trunk telephone subscribers. The dial office network must then be able to accommodate all such extensions in its numbering plan. A state of interdependence here exists between the numbering of ordinary single-trunk telephone subscribers and that of PABX extensions.

If fixed numbering were to be applied systematically, PABX's adapted for direct inward dialing for 10 to 100, 100 to 1,000 or 1,000 to 10,000 extensions would have to be allocated the last 2, 3 or 4 digits in the numbering plan of the dial office network. However, other solutions are conceivable in which up to 100, 1,000 or 10,000 numbers could be allocated from the numbering plan of the dial office network.

With free numbering, the proprietor of any PABX adapted for direct inward dialing may allocate call numbers to his extensions completely without regard for those of other PABX's or the numbering plan of the dial office network. Each such PABX is allocated – the same as PABX's not adapted for direct inward dialing – a single directory number from the numbering plan of the dial office network. Each trunk-access PABX extension is then simply allocated a number that is added as a suffix to this directory number; the length of the extension number will depend on the size and organization of the firm renting the PABX.

Given free numbering, the 2, 3 or 4 digits required with a PABX adapted for direct inward dialing for 10 to 100, 100 to 1,000 or 1,000 to 10,000 extensions could be suffixed to the last digit of its directory number. Extension numbers can naturally also be inserted following the next-to-last, second-from-last or third-from-last digit of the directory number. This "shift" in the numbering plan of the dial office network is not forced as with fixed numbering, but can be chosen arbitrarily according to considerations of organization or technology.

Numbering methods and organization

Fixed numbering brings about a close relationship between the development of public and private telephone networks. In all of its plans the PTT or telephone company must allow at the outset for the growth of PABX traffic of private business and civil service organizations. This is necessary, for instance, because the proprietors of PABX's are not here free to decide how many PABX extensions should be installed on their premises; in certain cases they are not even free to choose the numbers to be allocated to their trunk-access extensions.

The particular arguments in favor of fixed numbering are that, despite direct inward dialing to PABX extensions, it allows call numbers of equal length to be allocated to PABX extensions and ordinary local subscribers alike, and that the heavy traffic flowing to PABX's adapted for direct inward dialing affects only a few group selector stages at the dial office. In many cases the first argument is used less on organizational grounds than with a view to the technical features of certain dial systems (cf. next section). Systematic investigations have shown that, from the organizational standpoint, it is even disadvantageous to allocate numbers of equal length to all parties. Instead it is preferable that parties that are called frequently should be allocated numbers that are as short as possible, while parties that are called only occasionally should be allocated longer numbers. The object here is to reduce to a minimum the average number of digits that have to be dialed as a whole. The second argument is true in a quite general sense and can be used in favor of free numbering just as well as fixed numbering.

With free numbering, dial office networks and PABX's are able to develop in complete independence of each other despite direct inward dialing to PABX extensions. Neither the PTT or telephone company nor the proprietors of PABX's are, in principle, required to make allowances for each other in their private planning. PABX proprietors can choose freely how many extensions should be installed on their premises and the call numbers to be allocated to them.

With free numbering, the length of call numbers can be adapted not only to the existing state of growth of PABX's but also to the rate with which the various extensions are called. The traffic fed from a dial office to a PABX adapted for direct inward dialing can be directed over switching stages that recommend themselves from the organizational standpoint; in the case of direct-pulsing systems, for instance, the 1st, 2nd or any other group selector stage may here be chosen.

Considered from the organizational standpoint, any form of fixed numbering is thus superior to free numbering. This situation is not very different if considerations stemming from the dial system technique used are also taken into account.

Numbering methods and technique

Fixed numbering will as a rule be required where dial offices can handle directory numbers of only a certain length. Such limitations may be due, say, to the limited storage capacity of registers. If registers can store and retransmit numbers of only a certain length, the call numbers allocated to PABX extensions must not exceed this limit.

The first time a PABX proprietor on a network operating with registers of this type applies to have his PABX adapted for direct inward dialing, there will be a natural desire to accede to this request with the aid of the existing registers. The trunk-access PABX extensions would thus be allocated call numbers of a length that the registers can handle. Drawn from the reserve originally provided with a view to the natural growth of the dial office network, such call numbers would here be allocated to

a single "large subscriber" instead. This course has, in fact, already been taken in such cases [2, 3, 4].

If it is to be expected that quite a number of PABX's on a network operating with registers will have to be adapted for direct inward dialing, liberal provisions must be made. These may involve, for instance, expanding the storage capacity of registers or adding more registers. This calls for considerable outlay but may prove economically acceptable if the favorable influence of direct inward dialing on the traffic load of the dial office network is taken into account (shorter average holding time).

The possibility of including call numbers for PABX extensions in the numbering plan of the dial office network has been voiced of late in discussions on electronic switching systems [5]. Such arguments are favored by the many potentialities offered by centralized logic systems, and also by ideas connected with the electronic concentrator technique [6].

It is pointed out that the logic and the storage hardware of electronic control devices can be utilized best when they are centralized as far as possible. The assignment of separate electronic control units to relatively small groups of PABX's, concentrators, or similar switching centers at present appears uneconomical.

Such ideas should, however, take account of the fact that discussion concerning the economically and technically favorable ranges of application of electronic dial office equipment is still at a very early stage. The clear organizational advantages offered by free numbering in connection with PABX extensions should rather encourage development departments to design systems that allow it.

The free numbering of PABX extensions is readily possible if the dial office equipment can handle call numbers of any length. This is naturally the case with all direct-pulsing systems. For systems operating with registers or other numerical storages various solutions are feasible.

Recourse could be taken, for example, to buffer storages capable of receiving and retransmitting call numbers of any length. Another solution is to cut in a number of registers in succession in fixed sections of the connecting path; as with a direct-pulsing system, each line section must here be connected through before the subscriber begins to dial the digits required for the next register or storage.

The EMD system M [7] operates with buffer storages. In the German nationwide dial office network, buffer storages are also used for all digits following the office code [8].

In solutions involving registers or storages that are cut in progressively, an allowance must be made for the time required for the operation of the switches or switching array in the talking paths. For operating times in the order of interdigit pauses (hunting period) or thereabouts – between about 50 and several 100 msec – it will be necessary either to use individually assigned storages [9] or to assign the storages in common to relatively small groups of switches. Also common control devices (markers) should in such cases be assigned to suitably small groups of switches.

In the case of operating times in the order of only a few msec, the storages and control devices can be used with a wide margin of freedom on a more or less common control basis. Operating times as short as this are of particular interest for semi-electronic switching. Magnetic field arrays operating with high-speed noble-metal relays (ESK) [10] or dry reed contacts [11] meet time conditions of this order.

With full-electronic switching systems the speed of operation is naturally sufficient to allow the use of storages and control devices as required.

The technical features mentioned show that the free numbering of PABX extensions is today readily possible in many switching systems used for dial office networks. Provision for free numbering can also be made without difficulty when designing future system. Fixed numbering, which is of course likewise technically possible in any switching system with free numbering, will in all probability be necessary in certain switching systems now in use or will not be avoidable except at considerable cost. All new development work should therefore bear in mind from the outset that switching systems which permit free numbering clearly offer more degrees of freedom.

Rate indication for PABX's adapted for direct inward dialing

Rate indication in PABX's adapted for direct inward dialing depends first of all on the same questions that are of common interest for all other types of PABX's [12, 13]. In addition, direct inward dialing to PABX extensions gives rise to an administrative problem, for two different views may exist as to exactly when the metering of calls dialed direct to PABX extensions should actually begin. Metering can be initiated at any of various stages in the establishment of the connection:

1. when the number of the wanted extension is dialed after the call has reached the PABX from the dial office network;
2. when the dialed extension answers or, if the PABX attendant is dialed, when the attendant answers.

In this connection it should also be considered whether a call that reaches a PABX but encounters a no-circuit condition or finds the wanted extension busy should be

3. automatically rerouted (without any action on the part of the calling party) to a predetermined extension such as the attendant telephone;

4. whether such rerouting should be initiated in all cases or only in the case of, say, incoming long-distance calls.

In general these questions must first be considered from the standpoint of traditional and statutory concepts regarding call charges. Technical solutions to all such problems are available and have also already found practical application.

Practical experience with direct inward dialing in German PABX's

In Germany the first PABX's adapted for direct inward dialing were introduced in 1925, Siemens & Halske having played an important part in this development. Specifications governing direct inward dialing worked out by the Munich department of the Central German Telegraph Office on the basis of proposals made by M. Hebel [1] proved extremely satisfactory. Free numbering was here one of the essential features specified.

Still adhering to the same specifications, the West German Post likewise permitted direct inward dialing for all large PABX's after 1945. Trunk-access PABX extensions adapted for direct inward dialing can now accordingly be dialed directly not only by any telephone subscriber on the local dial office network but – by way of the direct distance dialing network – also by any subscriber anywhere in West Germany; provision is even made to enable subscribers in other countries to dial straight through to PABX extensions in Germany.

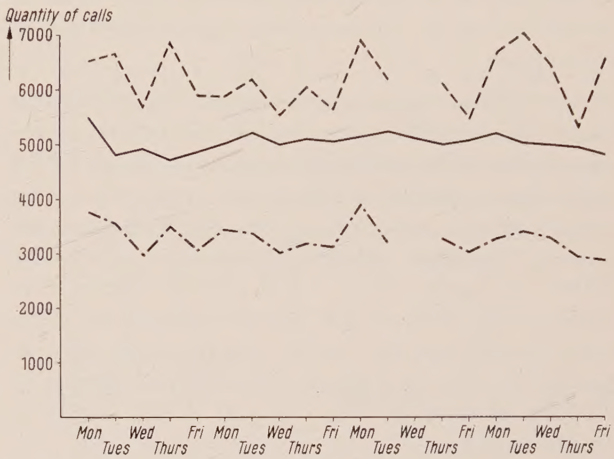
PABX's adapted for direct inward dialing are usually connected to the last group selector stage (before the line connector) of the local dial office. This is not done on account of technical numbering considerations but because group selector stages are arranged from the outset so that they can pass on dial pulses or allow them to pass. The consideration that the respective PABX's can consequently be assigned a shorter directory number is here only a secondary one.

In local networks with, say, 6-digit directory numbers, PABX's adapted for direct inward dialing are thus reached on dialing four digits. This means that, when a PABX adapted for direct inward dialing is installed, two digits – the tens digit and the units digit of a certain hundred – have to be allocated from the reserve numbers of the dial office network. This is one of the reasons why direct inward dialing is so far permitted only for large PABX's with capacities from 100 extensions to infinity.

A 4-digit number such as this – also a 3-digit or 2-digit number in the case of small local networks – that has been allocated from the numbering plan of the local dial office network represents the call number of the PABX.

As the number of the wanted trunk-access extension can be dialed immediately after it, it is also sometimes termed the "direct inward dialing number". Such numbers can be of any length except that the digit 1 is set aside in all PABX's adapted for direct inward dialing for calling the PABX attendant. The numbering scheme for PABX's adapted for direct inward dialing and their PABX extensions will thus as a rule be as follows:

Call number of same length as directory numbers of local single-trunk subscribers
minus two digits
plus any quantity of digits for reaching trunk-access PABX extensions
or
plus digit 1 for reaching the PABX attendant.



—— Quantity of calls answered by PABX attendants prior to introduction of direct inward dialing
-·-·- Quantity of calls answered by PABX attendants four months after introduction of direct inward dialing (3rd Wednesday was a public holiday)
– – – Total quantity of incoming trunk calls four months after introduction of direct inward dialing (3rd Wednesday was a public holiday)

Fig. 1 Success of direct inward dialing in a large PABX is reflected in the reduction in trunk calls answered by PABX attendants

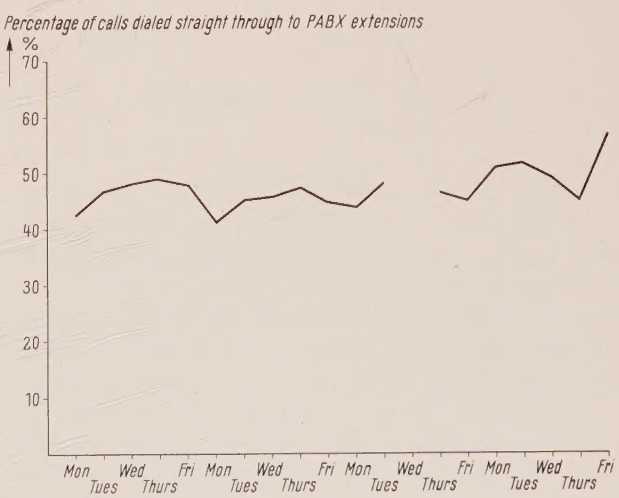


Fig. 2 Percentage of calls dialed straight through to PABX extensions four months after introduction of direct inward dialing in a large PABX

Outlets of group selector stages that are to give access to PABX's adapted for direct inward dialing are wired to direct-inward-dialing relay repeaters. In addition to performing all the functions of the normal relay sets of line connectors in dial offices, these relay sets also interoperate directly with the devices of the PABX adapted for direct dialing. The relative circuit specifications – uniform for all types of PABX's – were established by the West German Post.

Practical experience with direct inward dialing has been entirely satisfactory and it has already been adopted by many large industrial organizations, municipal authorities, civil services, German electricity supply companies, and, above all, the West German railroad, which operates one of the largest private telephone systems in the country.

Experience has shown time and again that, within six months of the introduction of direct inward dialing, the proprietors of large PABX's require far fewer PABX switchboard attendants [14]. Even within this short period, outside business associates will come to prefer to dial 60% of their calls straight through to the wanted PABX extensions. Figs. 1 and 2 show statistics on Cologne City Hall's PABX, which is adapted for direct inward dialing and was placed in service with 1,500 extensions in 1959 [15]. Many other technical reports on PABX's adapted for direct inward dialing testify to similar experience.

PABX's where incoming trunk calls are answered by the attendant and transferred to wanted extension have naturally always been independent of the numbering plan of the dial office network. With the introduction of direct inward dialing it is desirable that this organizational advantage should as far as possible be retained. In developing new switching systems it will be worth while to devote particular attention to this point.

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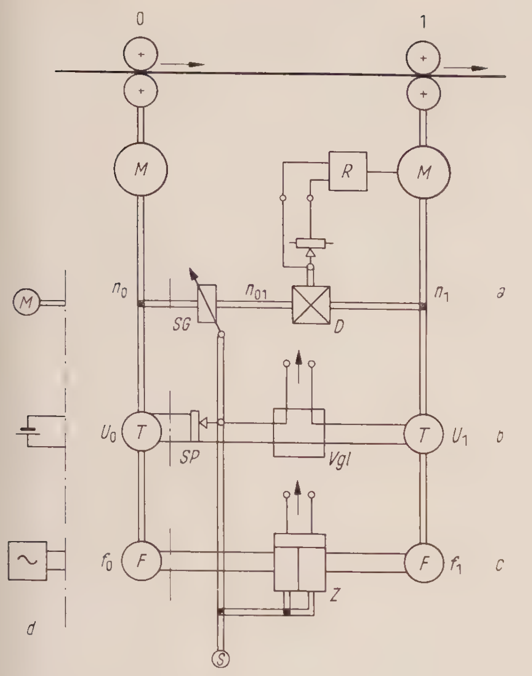
Digital Speed Control

BY KLAUS ANKE, GERHART KESSLER AND HELMUT MÜLLER

In present day production processes proper speed control of drive motors is absolutely indispensable. As is the case in many other fields of control engineering [1], the requirements made in control systems with regard to transient and steady-state accuracy are steadily increasing. Thus, for instance, in the fibrous materials industry, and particularly in the manufacture of paper and plastic foil, it is frequently required that the speeds of individual drive motors operating in groups be accurately synchronized. On paper machines the ratio of the speeds of associated drive groups has to be adjusted continuously within a range of a few percent and maintained constant for a long period with a steady-state accuracy of a few tenths per mille, since deviations in speed can cause the paper to crease or tear. In the processing of plastic foils the ratios of the speeds of adjacent rolls must be set at up to 1:3 and 1:5 and maintained with an accuracy of approximately 0.1%, even where the web speed may be varied within a range of 1:10 and more. Momentary disturbances must not cause more than limited transient changes in the quality of the material and make necessary a control system with extremely good transient characteristics. In many cases absolute ceiling speeds with a high degree of constancy are prescribed.

A simplified arrangement of the synchronous speed control of two individual drives is shown in Fig. 1. The speed n_0 of the drive 0 is predetermined, and the speed n_1



a Mechanical comparison of speeds (analogue)
b Electrical comparison of tacho-voltages (analogue)
c Electrical comparison of frequencies (digital)
d Master or reference quantities for control of absolute speed

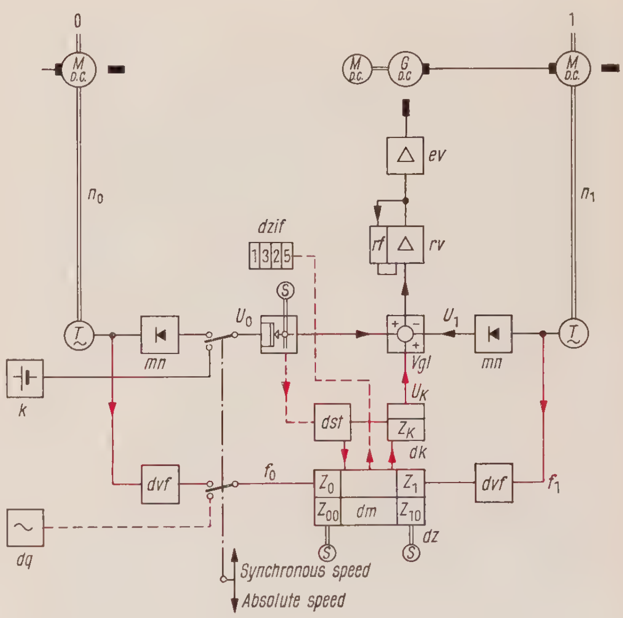
0 and 1:	Roll pairs with drive	*SP*	Reference potentiometer
M	Motor	*F*	Impulse transmitter
R	Controller (continuous-action)	*Z*	Counter (digital)
D	Differential	*S*	Reference setter
SG	Reference gear	n_0, n_1	Speed
T	Tachogenerator	U_0, U_1	Voltage
Vgl	Comparator	f_0, f_1	Frequency

Fig. 1 Control of the speed ratios of two drives

of drive 1 is regulated to the required value by motor *M* through the medium of controller *R*. The oldest and most common method employed with paper machines (*a* in Fig. 1) is based on the mechanical comparison of the two speeds by means of a differential unit *D* which acts on the controller via a setting device. The integrating action of the differential unit ensures that the ratio $n_1 = n_{01}$ is maintained under all conditions. The speed n_{01} must be derived from the master or reference speed n_0 through a gear unit *SG*, the continuously variable transmission ratio of which thus determines the ratio of the speeds n_0 and n_1. The accuracy of the speed relationship is here determined by the accuracy of the mechanical gearing. In the form of conical belt drives, gears of this type have a very high degree of accuracy over a small range but require mechanical positioners and thus maintenance. In systems introduced recently the mechanical differential is replaced by an electrical differential, an arrangement which does not, however, obviate the employment of mechanical gearing [2, 3].

In the arrangement *b* shown in Fig. 1 the speeds are simulated by d.c. voltages U_0, U_1 of the tachogenerators *T* and compared in the comparator *Vgl*, the difference being passed to the controller. Instead of being set by a mechanical gear unit, the speed ratio is set by a potentiometer *SP*. The comparison of the voltages and hence of the speeds is here carried out on the basis of proportional action. The steady-state accuracy of the speed ratio which can be attained is limited by systematic errors inherent in the tachogenerators (temperature, brush voltage etc.) and by inaccuracies in the control amplifiers. The quality of present-day equipment is, however, so high, that accuracies of ± 0.03% can be obtained over periods of 24 hours [4]. A particular advantage of this arrangement is that the control circuits contain only electrical elements which are simple to set and easy to accommodate.

The arrangements *a* and *b* shown in Fig. 1 are known as analogue systems because the control variables can be formed and processed continuously. The accuracy which can be attained with reasonable expenditure is limited by natural laws peculiar to analogue techniques. By means of suitable feedbacks in the electronic amplifiers (electronic tube, transistor, transductor amplifiers) the tran-



Analogue unit	*rv*	Control amplifier	Digital unit	*dz*	Counter
	rf	Feedback		*dk*	Correction unit
	ev	Output amplifier		*dst*	Control unit
	Vgl	Comparator		*dvf*	Multiplier
	mn	Transducer		*dq*	Constant frequency (quartz)
	k	Constant voltage		*dzif*	Number indicator
				dm	Memory unit

0 and 1	Drive	U_0, U_1, U_k	D.C. voltage
T	A.C. tachogenerator	n_0, n_1	Speed
S	Reference setter	f_0, f_1	Impulse frequency
Z_0, Z_1 / Z_{00}, Z_{10}, Z_k	Number		

Fig. 2 Synchronous speed drives with analogue control circuit and digital unit

sient response of this control system can be increased to such an extent that it is possible to meet practically all requirements with regard to speed of correction.

Digital control systems are capable of meeting extremely stringent requirements with regard to maintenance of accuracy and reproducible reference settings, even over a period of days and weeks.

With the digital method of speed control, the actual value is not supplied by a tachogenerator in the form of current or voltage but is obtained by counting the number of cycles of a frequency which is proportional to the speed. The accuracy attainable is thus given by the product of the possible frequency and time available. In the case of an electric drive, the speed (angle of rotation per time unit) is simulated digitally in a simple manner by so co-ordinating transmitter impulses with the angle of rotation that the speed is proportional to the impulse frequency. In Fig. 1*c* the speeds are simulated by the frequencies f_0 and f_1 and compared in a counting device Z. To obtain the required ratio of synchronism, a reference ratio f_1/f_0 must be maintained. Deviations are passed to the controller for correction, as was the case previously. If a continuous-action controller is used, the control deviations determined digitally must first of all be converted into analogue quantities before they can be processed by the controller.

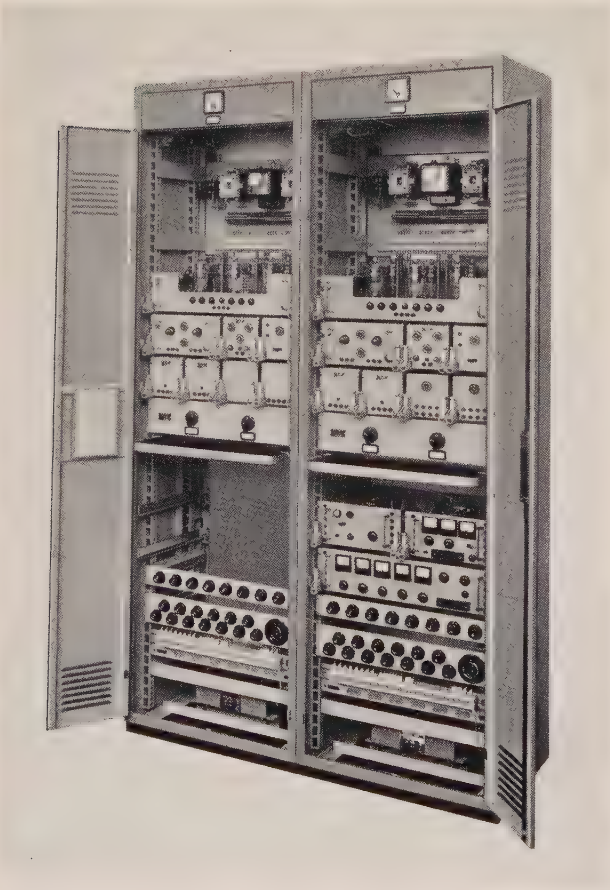


Fig. 3 TACHOTRON electronic control device. Control cubicles for two sectional drives on paper machines: left-hand side, analogue unit alone; right-hand side, with digital unit

The transient response of this digital control system is determined by the required frequency and accuracy. If, for instance, the frequency f_0 is equal to 1,000 cycles and the accuracy is 0.01%, a counting time of 10 seconds is necessary before the smallest deviation can be detected and the controller can make the correction. If the rise time of analogue circuits (less than 0.1 second) is to be attained, very high frequencies are required for the same degree of accuracy, particularly when a wide speed range has to be covered. A more advantageous method is to combine the arrangements *b* (analogue) and *c* (digital). With analogue control it is quite simple to obtain good transient response and very small steady-state errors which do not, however, always meet requirements adequately. Since these have an inherently slow variation, a long correcting time suffices and the correction can be carried out with the desired accuracy by the digital measuring device operating at low frequency.

This combination has the advantage that the digital unit can be added to any standard analogue control system; in the case of sectional motor drives, for instance on paper machines, it is advisable to employ it only for those sections where high accuracy is a real necessity. For the control of one motor alone a master motor, reference voltage or reference frequency is employed in place of the speed n_0 shown in the left on Fig. 1.

Fig. 2 shows the construction of an analogue speed control system with superordinated digital control. Drive 1 is fed from a Ward-Leonard generator which is, for instance, controlled via a transductor output stage *ev* and a control amplifier *rv* with feedback *rf*. The speeds are simulated in analogue form via a.c. tachogenerators T and transducers *mn*. After division in the reference setter S, a difference is formed in the comparator *Vgl* and passed to the controller. The impulse frequencies f_0 and f_1 for the digital unit are taken from the same tachometer generators and, where necessary, passed via multipliers for low speeds to the counter *dz* in which two registers starting simultaneously summate the impulses of f_0 and f_1 to the numbers z_0 and z_1. When the number z_0 reaches the adjustable clock number z_{00} (e.g. 1,000), both counters are stopped.

If, in the time resulting from this, the actual number z_1 reaches the set reference value z_{10} (e.g. 1,100), the mean value of the speed ratio $n_1/n_0 = z_{10}/z_{00}$ (= 1,100/1,000), measured with an accuracy of one impulse (0.1%). If z_1 has not attained the reference number z_{10} within this time, or if it has already exceeded it, the difference $z_{10}-z_1$ is passed as an integrated quantity with the correct sign

to the counter of the correcting unit *dk*. The digital correction z_k produced there is converted into an analogue correction voltage U_k and fed via the comparator (*Vgl*) into the analogue circuit.

The clock number z_{00} determines the accuracy and, together with the reference number z_{10}, the speed ratio. Together with the reference figure, the analogue setter *S* must also be set approximately to the reference value to ensure that the correction range of U_k is adequate. In many cases, particularly in the case of paper machines, the exact reference value is not known beforehand, but must be set according to the condition of the web. In order to retain the quick setting time of the analogue system, the arrangement adopted in this case is such that only the analogue reference setter *S* is used. When this is adjusted, the digital measurement is switched off simultaneously and switched on again after an interval. The ratio set in analogue form is then measured by determining the actual number z_1 attained during the measuring period (up to the point when z_{00} is attained) and stored in a memory unit *dm*. In the following measuring interval it then serves as the reference value z_{10} for the control correction described (reference value by measurement). The reference number can be indicated in a panel on the reference setter. If the required reference number is known, it can also be set by means of control switches (reference value by setting).

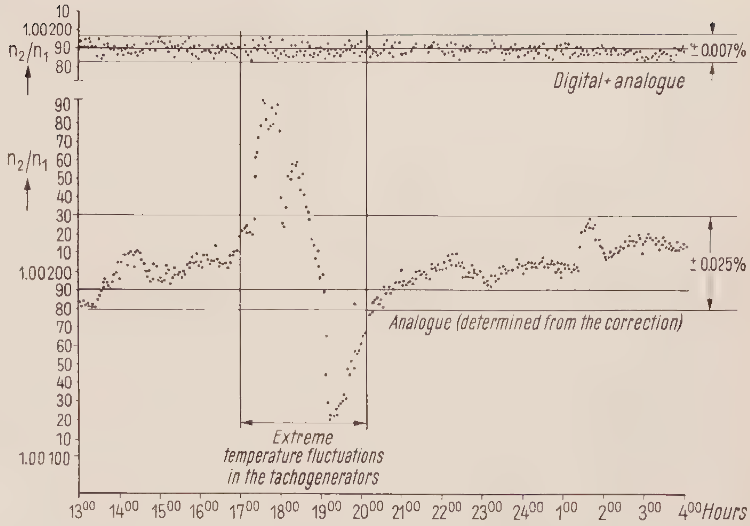


Fig. 4 Measuring the speed relationship n_2/n_1 of the drives of two dryer groups on a paper machine

The digital unit is constructed mainly of Simatic* components which guarantee a high degree of reliability [5].

Fig. 3 shows the control cubicles for digital supervision of the drives of a paper machine within a speed range of 1 to 10. The left-hand cubicle contains the normal analogue controller, which in this case is of the electronic tube type [4, 6]. The right-hand cubicle contains in the lower section the additional digital control device as shown in Fig. 2 which is accommodated in a number of replaceable functional slide-in trays. When the digital unit is switched off, operation can be continued with the analogue controller. The device can be set to an accuracy of 0.1 to 0.01% and operates with a tachogenerator frequency of 750 cycles at 1,500 r.p.m.

The results of measurements taken on a paper machine over an extended period are shown in Fig. 4. Each point represents the mean value of a separate measurement with an accuracy of 0.001% over approximately 100 seconds. During this period the controller completed ten measurements and corrections with the clock number set at $Z_{00} = 10^4$. The upper series of points shows the speed relationship of two dryer groups as obtained with an analogue-digital combination over a period of 15 hours with a deviation of ± 0.007%. The lower series of points shows the relationship without digital control; this was determined from the correction. It can thus be seen that the deviation is ± 0.025% which corresponds to the accuracy obtainable with tachogenerators. Between 17^{00} and 20^{00} hours a large fluctuation was caused by extreme temperature changes in the tachogenerators. There is no sign of this in the upper series. It should be noted here that the improvement lies not only in the ratio of 0.007 : 0.025 but also in the fact that the accuracy attainable with digital control can be maintained over any desired period. By setting the same reference number, the same value can be reproduced, even after interruptions in operation.

These equipments represent a further step forward to technical perfection and permit accurate control of speeds and speed ratios within a wide range, independent of disturbances.

* Trade-mark

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Digital Position Control

By Klaus Anke, Karl Ertel and Gerhard Sinn

An important field within control engineering is taken up by what is known as "Position control". Examples of position control can be found in all branches of engineering: all follow-up controls, for instance, are of this type; with machine tools special terms such as positioning and contouring have arisen; the screwdown of the rolls in a mill stand, winders, elevators and, in recent years, loading machines of nuclear reactors also create problems to be solved by position control.

The classic actual-value measuring units for position control systems are limit switches, potentiometers and synchros. By means of these alone or with the aid of control amplifiers it has been possible to overcome the tasks so far set such equipment. The accuracy of control obtained was generally in the order of 1 percent. By taking particular care in selecting the desired-value and actual-value data and in forming the differential value, accuracies of up to a few thousandths could be achieved.

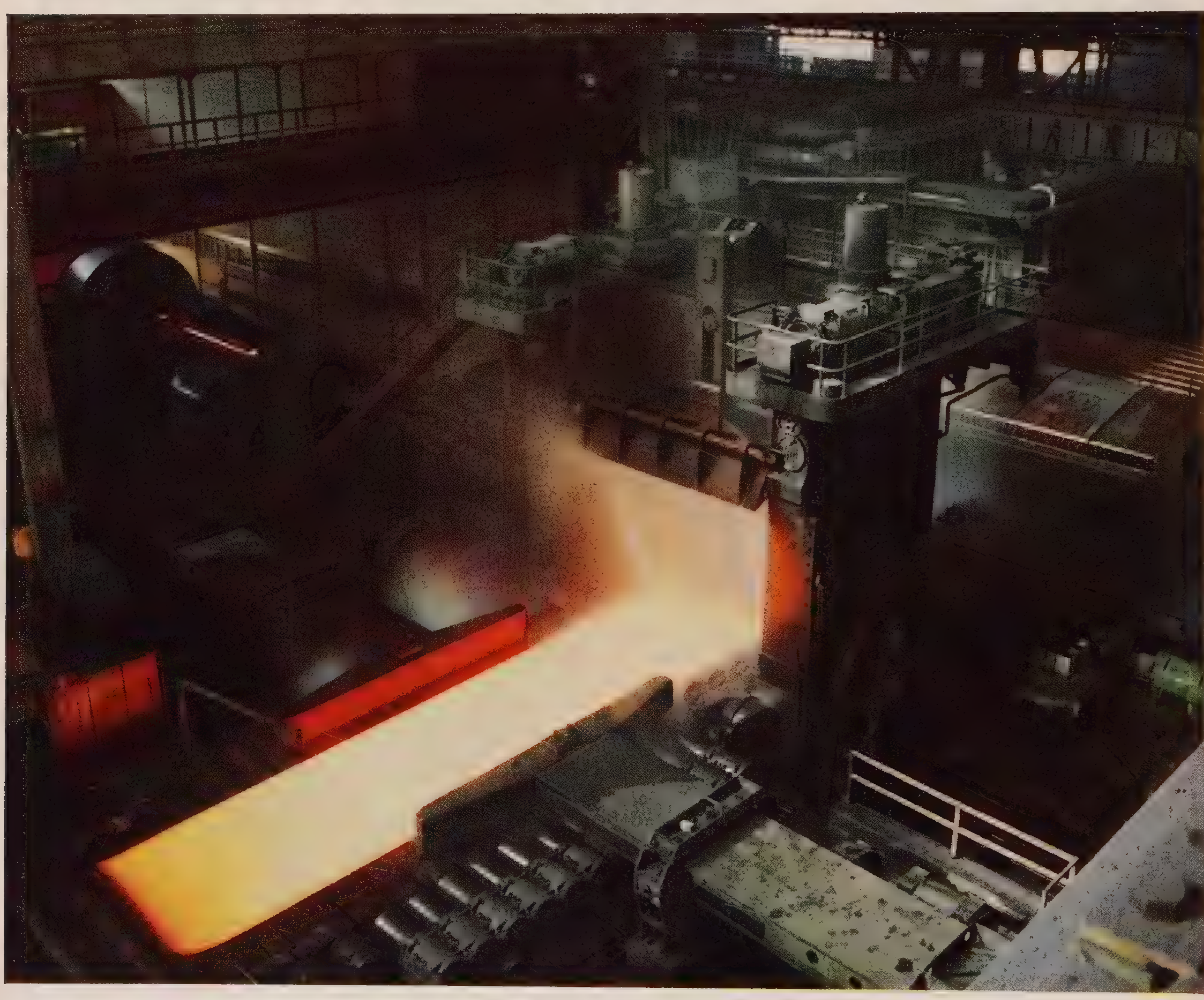


Fig. 1 Plate mill. Each time the ingot or plate has passed through the stand, the top roll must be adjusted so that the desired draft is obtained at the next pass

It soon proved, however, that higher degrees of accuracy, while retaining the same speeds, could not be achieved with these classic analogue means, or, if obtainable, then only by employing means which in many cases were practicable neither from an economic nor technical point of view.

Nowadays, however, such great accuracy requirements have to be met and overcome, for instance, in the positioning of machine tools and screwdown in rolling mills. The usual accuracy requirements in such cases range from tenths of thousandths to, in special instances with certain machine tools, hundredths of thousandths. A new type of control system had to be found to fulfill these tasks. This was done by applying digital control which increases the accuracy of control far beyond previous limits.

With digital distance measurement, the linear distance in question is subdivided into distinct increments by suitable measuring elements and can thus be counted numerically. Consequently, a number is used as measure for the controlled condition instead of a corresponding current or voltage amplitude employed previously with analogue equipment. In addition to the increased accuracy, a second requirement arose, which accelerated the introduction of digital control systems: In many control applications there arose a desire to be able to set a reference value which was favourable for a particular technological process and which could be reproduced even after long time intervals. A suitable medium for the setting of repeatable, fairly well-defined input values, is the number or digit which is superior to analogue media in this respect also.

The numerical desired value and the numerical actual value are processed in the digital control system to form the numerical or digital deviation. The point of the control loop at which eventual conversion to analogue quantities takes place and the extent to which the digital part participates in enforcing the desired speed of control depend on a number of secondary conditions.

The screwdown of a reversing mill stand

The following contains a detailed study of some of the problems specifically associated with digital control, taking the roll screwdown of a reversing mill stand as example, and applies also for all the other position control tasks mentioned at the beginning of the article.

In the case of the reversing stand (Fig. 1) the top roll must be adjusted after each pass of the ingot or plate so that, at the next pass, the desired reduction in the thickness of the ingot or plate is obtained. It is important from an economic point of view for the entire rolling process that the number of passes required to roll the ingot from its initial dimensions to the desired final dimensions be kept to a minimum. The time lost between the passes must also be kept as short as possible.

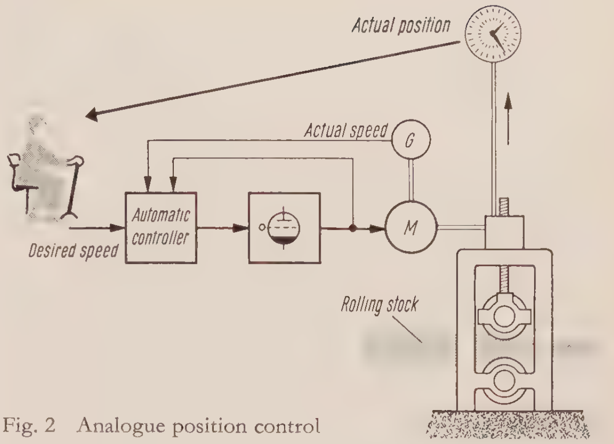


Fig. 2 Analogue position control

The maximum permissible draft, i.e. the reduction in roll opening between two passes, is determined not only by the design of the mill stand itself, but also by the nature of the material, the temperature and the dimensions of the ingot prior to the pass. The more accurately the screwdown gear can be adjusted to a desired position, the smaller is the safety margin from the maximum permissible draft. This means that, by increasing the accuracy of the screwdown, the number of passes can be reduced. In addition, a definite accuracy is demanded for the final dimensions – in modern reversing stands this is generally 0.1 mm, referred to a maximum roll opening of 1 metre, i.e. 0.01 percent.

Screwdown is effected from the control platform. The operator is familiar with the rolling programme and

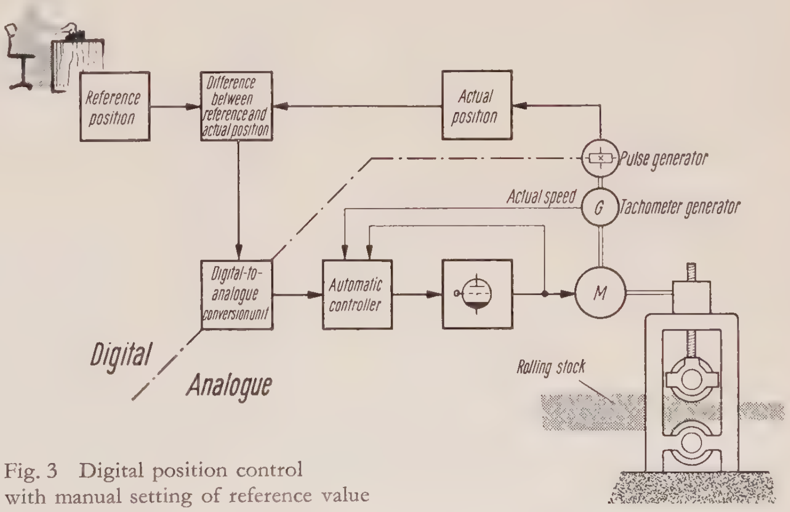


Fig. 3 Digital position control with manual setting of reference value

knows the permissible drafts between successive passes. The actual roll opening can be read off on a mechanical indicator (Fig. 2). By means of a control lever, the reference speed signals are fed to the automatic controller in order to set the rolls to the new position. The accuracy and rapidity with which the new actual position is reached depends not only on the good dynamic characteristics of the speed control, which is best of the transistorized type [1, 2], but also to a considerable extent on the experience and skill of the operator. After a certain amount of practice he is generally able to obtain short positioning times; the required accuracy, however, will not always be achieved. In addition to this, the demands placed on the operator's powers of concentration are so great that the screwdown gear is adjusted alternately by two men during one shift, particularly since the operator also has other tasks to see to over and above screwdown, e.g. operation of the descaling spray equipment and control of the manipulator.

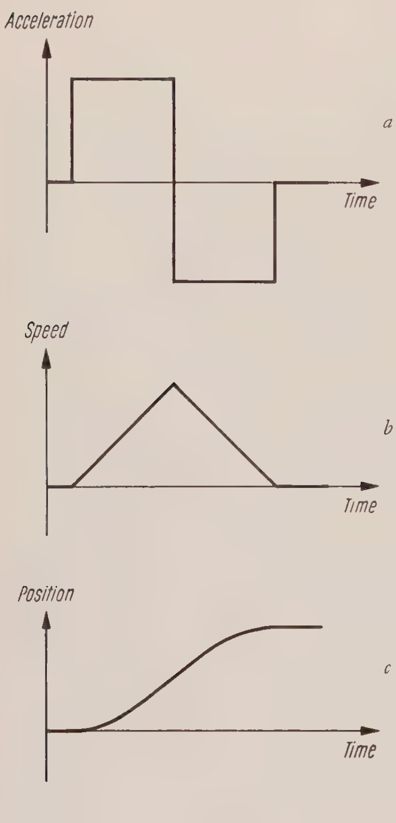


Fig. 4
Ideal characteristic curves for position controls

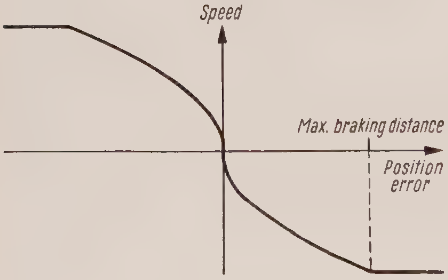


Fig. 5 Parabolic curves showing the ideal interrelation between position error and speed

An important task of the digital control equipment is therefore to relieve the operator of certain duties and to ensure the desired accuracy at a minimum positioning time. In this case the control loop is no longer closed by the operator but by the digital control units (Fig. 3). The distance is subdivided into increments of 0.1 mm in this case and is measured by counting the number of the pulses; the roll opening is thus stored as a number in an actual-value register and indicated. The actual value can either be supplied from a pulse generator with cascaded counter or from a measuring device in which direct digital co-ordination of the linear position takes place. In the first case, the direction of the required movement must be derived from the pulse train.

The new desired value is preset in numerical form before screwdown is started. This can also be done in the course of the preceding screwdown or rolling operation. The new value for the roll screwdown is preset either as an absolute value (desired roll opening) or as differential movement (desired alteration in the roll opening).

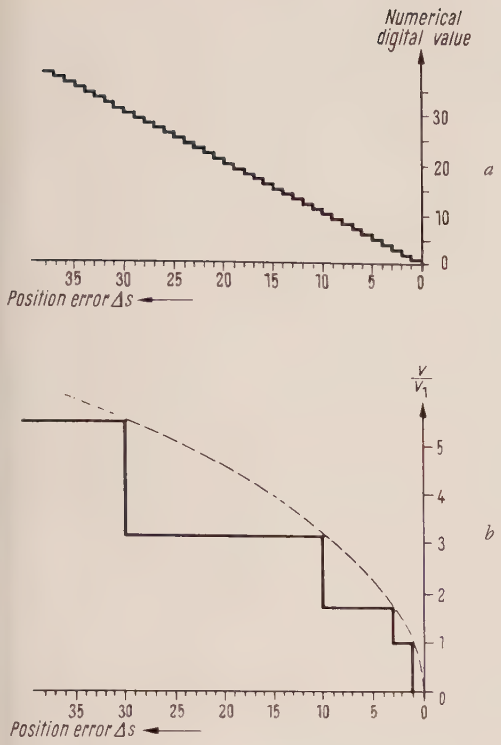
As soon as the new value has been fed in and the ingot has left the stand, the automatic control can be switched on either by the operator depressing a pushbutton or automatically by the rolling operation itself. The difference between the preset reference value and the instantaneous actual value – the position error or deviation – is converted from a number into an analogue speed reference and fed to the automatic controller.

The adjustment of the rolls is initiated by the automatic controller via mercury-arc converters, for instance.

The number stored in the actual-value register is changed in accordance with this adjustment. The position error or deviation, which is always determined by the difference between the actual and desired movement, becomes smaller. This continues until the difference between the actual and desired movement is zero, i.e. until the roll opening has been adjusted to the new reference value. Here the automatic controller has the task of reaching this value in the shortest possible time without overshoot.

Ideal time characteristics of the position control

Elimination of a position error within the shortest possible time is achieved when the servomotor is operated with maximum (constant) permissible acceleration during the first half of the required movement and then with an equally large amount of retardation during the second half of the required movement. Fig. 4*a* shows the acceleration/time characteristic. Ignoring the rise times, this acceleration characteristic corresponds to the speed and distance diagrams shown in Figs. 4*b* and *c*. From



a Output of the difference counter
b Output of the digital-to-analogue conversion unit

Fig. 6 Digital values at the output of the differential counter and of the digital-to-analogue conversion unit as a function of the position error

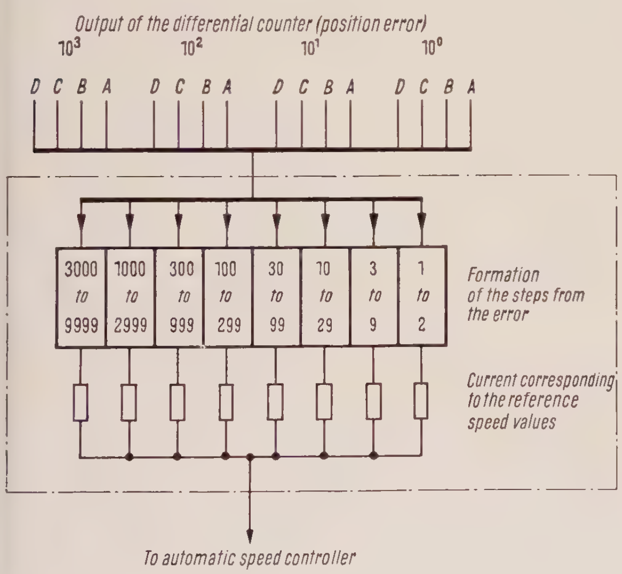


Fig. 7 Structural arrangement of a digital-to-analogue conversion unit with various incremental steps according to Fig. 6

these two diagrams is obtained the ideal position-error/speed characteristic in the form of two parabolic branches (Fig. 5). The digital position error must then be converted into an analogue speed reference corresponding to this parabolic curve.

Digital-to-analogue conversion unit

With the digital system the parabolic curve is approximated in steps.

Often the difference in position is given as a decimal code (corresponding to the set and actual position) so that the subdivision of the distance is best adapted to the decimal system. Since with the decimal system a 40-percent time loss must be expected in the most unfavourable case, a finer subdivision is necessary in order to obtain shorter positioning times. With an additional step in each decade, the maximum positioning times remain less than 1.08 $T_{\min}$ ($T_{\min}$ is the minimum positioning time), when the additional step approaches the geometrical mean of the end points of the decade. Over a prolonged period of operation a mean time loss, which is smaller than the computed value, is obtained because of the statistical distribution of the movements from one position to the other. The structural arrangement of a digital-to-analogue conversion unit with distance steps of 1, 3, 10, 30 etc. is shown in Figs. 6 and 7. This arrangement can be obtained by using SIMATIC* components [3]. During the screwdown operation the digital-to-analogue conversion unit receives the numerical difference between the actual and desired values as input quantity.

Formation of the difference between the actual and set values

In digital control systems, only the statement "yes" and "no", or in binary code L and 0, are processed, and no continuum of values. Decimal numbers must therefore be represented by combinations of the two signals L and 0 in accordance with a recognized code. In order to form the difference between two numbers, digits of the same order are evaluated simultaneously or one after the other time-wise according to the rules of arithmetic.

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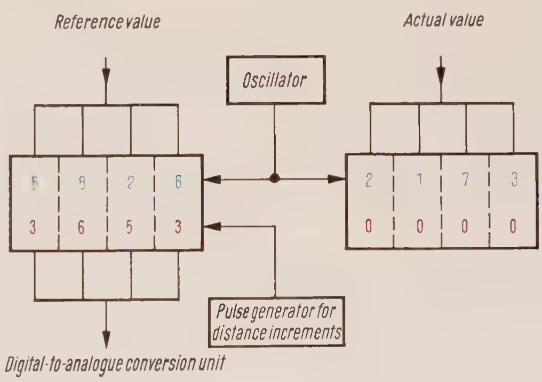


Fig. 8 Principle of the forming of the difference between the actual and reference values with two reversing counters. Numerical example: after set in (blue) and after counting (red)

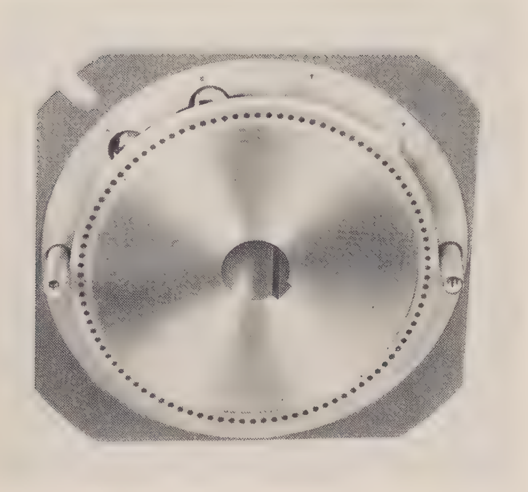
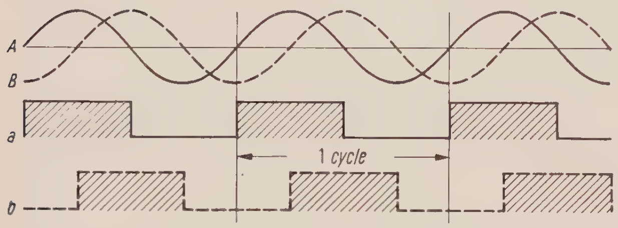


Fig. 9 Rotary digital data element with magnetic scanning device



Forward: $a \cdot \dot{b} \vee b \cdot \dot{\bar{a}} \vee \bar{a} \cdot \dot{\bar{b}} \vee \bar{b} \cdot \dot{a}$

$\dot{a}$ Change per unit time from $\bar{a}$ to a

Reverse: $a \cdot \dot{\bar{b}} \vee b \cdot \dot{a} \vee \bar{a} \cdot \dot{b} \vee \bar{b} \cdot \dot{\bar{a}}$

Fig. 10 Scanning system on the principle of the sine-cosine code

Another elementary method of subtraction or addition is counting. In this case, the difference, as required, for instance, by the digital control for linear positioning according to absolute values, can be formed by two counters and an oscillator (Fig. 8). During the control process the numerical deviation is counted back through the digital position measuring element. The well-proven semiconductor components of the Simatic system are available for the practical execution of the logical combinations on which the various methods are based.

Actual-value measuring unit

In order to obtain the numerical actual value a digital position measuring unit is required by means of which the total opening is resolved into a number of distinct increments. Measuring units which transmit the position directly in the form of a digital code are known as encoders. They are designed with photoelectric, magnetic or mechanical scanning systems. Pulse transmitters, which simulate the relative displacement according to the number of pulses in conjunction with a cascaded electronic counter, require less scanning equipment and generally have smaller moving masses. Such measuring units can be designed as glass or metal scales and sliders in linear form or as rotary data elements.

A rotary data element of this type is shown in Fig. 9. The permanent magnets of alternate polarity inserted axially in the light-alloy disc produce a position-sensitive sequence of signals in the two Hall generators A and B according to the sine-cosine code (Fig. 10) which can be evaluated as to direction of rotation and distance increment, for instance, by means of a Simatic circuit.

Programme store

The digital equipment is completed by the store of the reference values. In the simplest instance, this device retains only one reference value which is manually preset, for instance, by the operator for each adjustment.

With this method the operator has the task, before each pass, of reading off the new reference value from a pass schedule and feeding it into the store. If the operating personnel is to be relieved even further, the pass schedule can be kept at the ready in a programme store so that only a pushbutton need be depressed in order to feed the complete data for a new screwdown into the store (Fig. 11). The programme store can be built up of a number of rotary switch groups in conjunction with a step-by-step switching mechanism, which can be electromechanically or electronically operated, as desired. This arrangement, however, is only then satisfactory when the same programme is constantly repeated. If frequent changes are made in the programme, as is the case in a slabbing and blooming mill, it is better to store all the

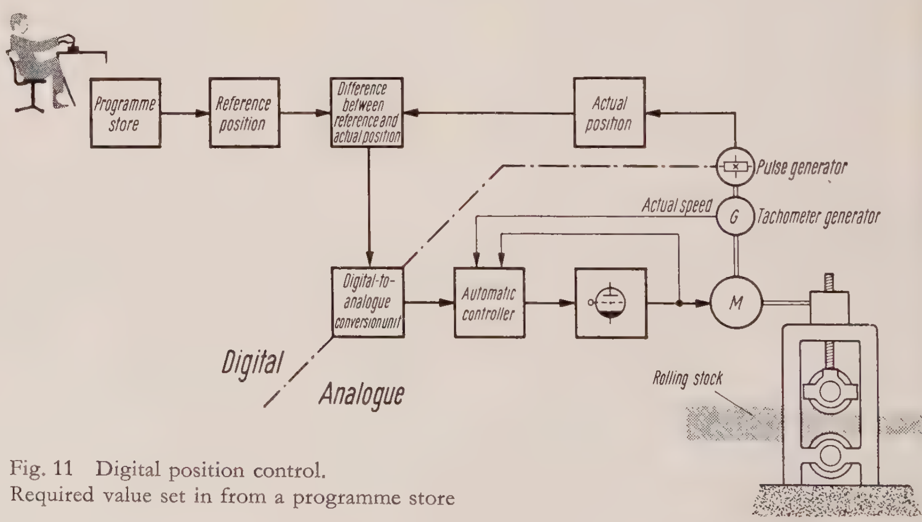


Fig. 11 Digital position control.
Required value set in from a programme store

pass schedules that may occur in a particular rolling mill in the form of punched cards, punched tapes or the like. In general, however, it is not advisable to feed values into the digital position control direct from the storage units; in this case an electronic short-term store or buffer device should be interposed [4]. The pass schedules are fed into this buffer from punched cards, for instance. An electronic buffer enables very short access times to be obtained when presetting the rolling programme. This is of considerable importance since there is very little time available between the last pass of one programme and the beginning of the rolling programme of a new ingot.

In addition to this, the use of a buffer reduces the mechanical stress on the scanning devices of the punched cards or tapes.

The digital position control in the form described relieves the operating personnel of many duties, simplifies operation of the machines and makes for increased production. The main significance of the digital position control, however, lies in the fact that the varying working steps required can now be fed into the control in the form of numbers from suitable storage devices, even in the case of comprehensive control programmes, enabling such processes to be included in an extensive automation of the plant.

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Transmission of Line Protection Signals over Powerline Carrier Circuits

By Reinhard Bartsch and Gerhard Bergmann

Powerline carrier terminals interoperating with selective protection relays D have for many years proved their outstanding capabilities in all applications where the rapid, reliable disconnection of troubled line sections is an essential factor. There are three different types of carrier terminals (Fig. 1):

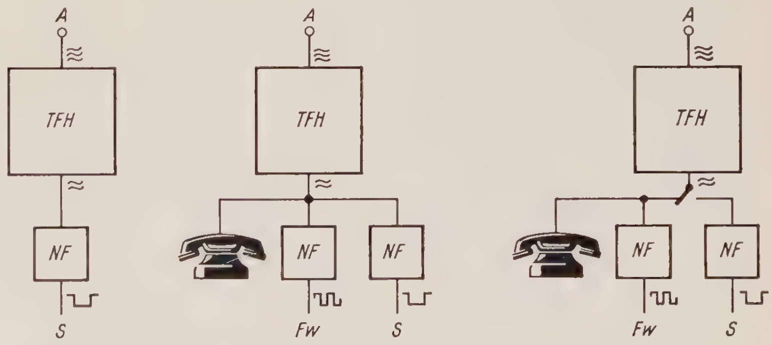
1. Single-purpose terminal (SP terminal) for transmission of line protection signals only.
2. Multi-purpose terminal (MPST terminal; ST = simultaneous transmission) for simultaneous transmission of speech, telemetering, and line protection signals.
3. Multi-purpose terminal (MPAT terminal; AT = alternate transmission) for alternate transmission of line protection signals or speech and telemetering signals.

The particular type of equipment to be chosen for a given application will be illustrated by reference to systems we have already installed.

Carrier terminals in line protection systems

General

Selective protection equipment is assigned to both ends of a powerline. When a short-circuit current develops within the network, this equipment initiates selective disconnection at either end of the faulted line or, in the case of a threephase system, disconnection of the faulted conductor only. In conventional time-distance protection systems the time elapsing between failure and disconnection ranges from one tenth of a second to several seconds. Short-circuit currents are mostly the result of transient arcing due, say, to thunderstorms. If the faulted line is disconnected rapidly enough at both ends for a period between 200 msec and 300 msec (automatic re-



Single-purpose terminal | Multi-purpose terminal, simultaneous-type | Multi-purpose terminal, alternate-type

TFH Powerline carrier terminal; *NF* V-f signaling attachment; *S* Protective signals; *A* to powerline; *Fw* Telemetering signals

Fig. 1 Types of equipment for transmission of selective protection signals

closure), the arc will in most cases disappear and power transmission will not be noticeably interrupted. Not more than 80 msec should elapse up to this short interruption (high-speed switching).

This high-speed response can be achieved with powerline carrier terminals which, interoperating with selective protection relays, either trip the switches at the distant station (intertripping system) or block their release (blocking system).

Principal features

With all three types of terminal the signals are transmitted over powerlines with the aid of carrier currents on which they are impressed either by amplitude modulation or frequency modulation. As known from other branches of signal communication, frequency-modulated signals are less sensitive to interference. Some carrier terminals are also provided with facilities for the effective suppression of false signals such as might be produced by noise bursts under short-circuit and arcing conditions. This is accomplished in the following manner:

1. The protective signal is transmitted with the maximum possible power.
2. An amplitude limiter at the input of the receiver clips the amplitude of the interference pulses.
3. A following narrow filter attenuates the clipped interference pulses considerably while the protective signal remains unaffected. The narrower the bandwidth of this filter, the more it attenuates interference pulses, but the longer is the signal delay time.

The characteristic features of the carrier terminals conventionally used for line protection are listed in Table 1. The individual terminals differ with respect to signal transmission in various ways.

SP terminals transmit only the protective signal and permit continuous supervision of the transmission channel. Maintenance is facilitated by functional design. The full send power is available for the protective signal. However, such terminals enter into action only for a small fraction of their operating time.

MPST terminals transmit speech, telemetering signals and protective signals simultaneously and channel supervision is likewise continuous. In contrast to SP terminals, these carrier terminals are multi-purpose. The high demands placed on the protective channel with respect to reliability tend to make maintenance more complex. Transmission reliability is somewhat inferior on account of the send power being shared between speech and telemetering signal transmission on the one hand and the protective signal on the other.

MPAT terminals are likewise multi-purpose but require a smaller overall bandwidth than MPST terminals and the full send power is available for the protective

Fig. 2 Carrier coupling at the 132 (380) kv station of the Agua y Energia Electrica in Morón, near Buenos Aires

Type of equipment	Model	Spectrum requirements for both directions of transmission	Output level per protective signal	Frequency swing per protective signal	Delay time of protective signal	Max. range for two protective signals in presence of interference***
		cps	db	cps	msec	km at 50 kc and 220 kv
SP terminals	FSK powerline carrier terminal	2×2.5	40 [10]	±300	<15	28...35 [745]
	FM powerline carrier terminal with v-f attachment *	2×5	34** [2.5]	±2000**	20	34...41 [925]
					<10	27...34 [720]
MPST terminals	SSB powerline carrier terminal with v-f attachment *	2×4	max. 38 [6.5]	±60	20	max. 22...29 [565]
				±120	<10	max. 15...22 [360]
	DSB powerline carrier terminal with v-f attachment*	2×8	max. 27 [0.48]	±60	20	max. 10.5...17.5 [230]
				±120	<10	max. 2.5...10.5 [25]
MPAT terminals	SSB powerline carrier terminal with v-f attachment*	2×2.5	40 [10]	±60	20	23.5...30.5 [615]
				±120	<10	16.5...23.5 [415]
	DSB powerline carrier terminal with v-f attachment*	2×5	30 [0.9]	±60	20	13...20 [310]
				±120	<10	6...13 [100]
	FM powerline carrier terminal with v-f attachment*	2×5	34** [2.5]**	±2000**	20	34...41 [925]
					<10	27...34 [720]

* V-f channels for protective signal transmission
** Common to both protective signals
*** Also includes interference voltages caused by switching operations

Table 1 Characteristics of line protection carrier terminals for two threephase systems

signal. Their disadvantage is that speech and telemetering channels are shut down during the transmission of the protective signal. This cannot be tolerated when, for instance, the terminal is used for telecontrol and telecounting as well. If both ends are not switched over simultaneously, the delay time of the protective signal is extended by the resulting time lag. The v-f facilities for the protective channels are monitored locally. Maintenance is as complex as with MPST terminals and for the same reasons.

Installed systems

The decision as to which type of terminal will best serve a given application depends on the local operating conditions of the h-t network, the determining factors being the admissible delay time of the protective signal and the maximum admissible line attenuation. By way of illustration, several systems already installed and the reasons underlying the selection of the equipment will now be described.

SP terminals of the Agua y Energía Eléctrica, Argentina

The San Nicolás steam power station on the Paraná river has a capacity of some 200 Mw and supplies the Buenos Aires city network some 130 miles away. Three parallel 132-kv open-wire lines transmit the power to the Morón main transformer station (Fig. 2) at the outskirts of the city. Within the city area the 132-kv transformer stations are supplied from a 132-kv underground cable loop which will subsequently also include the steam power station "Buenos Aires" now under construction.

In a network configuration such as this, high-speed disconnection of a faulted line irrespective of the location of the fault is possible only with the aid of powerline carrier terminals, for the conventional time-distance operation of protective relays would mean intolerably long disconnect times and so impair the stability of the network.

The use of powerline carrier terminals for protective signal transmission yields for each of the parallel open-wire lines (Fig. 3) an arrangement which, in case of a fault, selectively disconnects the faulted line from the network with a minimum of delay and reconnects it after a short interruption. If the fault condition recurs following reconnection, the line is finally disconnected at high-speed at both ends.

Fig. 3 132-kv powerline section between San Nicolás and Morón in Argentina. This section is scheduled for a subsequent changeover to 380 kv

The powerline carrier terminals were selected on the basis of the following considerations:

The delay time for the protective signal had to be kept at or below 15 msec. At a later stage of development two of the 132-kv lines interconnecting San Nicolás and Morón are to be changed over to 380 kv, with the carrier terminals used for the initial stage retained. The higher noise level to be expected after changing to the higher voltage had thus to be considered.

When the neighboring "Litoral" and "Córdoba" networks have been connected to this system, the line section from San Nicolás to Morón will become the backbone of the powerline carrier system. The overall network configuration demanded the use of frequency-conserving equipment operating with a uniform 5-kc frequency allocation plan.

For reasons of operational reliability, which depends in the case of protective signal transmission primarily on the signal-to-noise ratio, preference was given to SP terminals so as to insure that long-wave radio signals sometimes transmitted by ships on the Parana river will not cause false tripping.

All demands with respect to reliability were satisfied by the choice of powerline carrier terminals developed specially for protective signal transmission and operating on the frequency-shift basis. The system has been in operation since 1957.

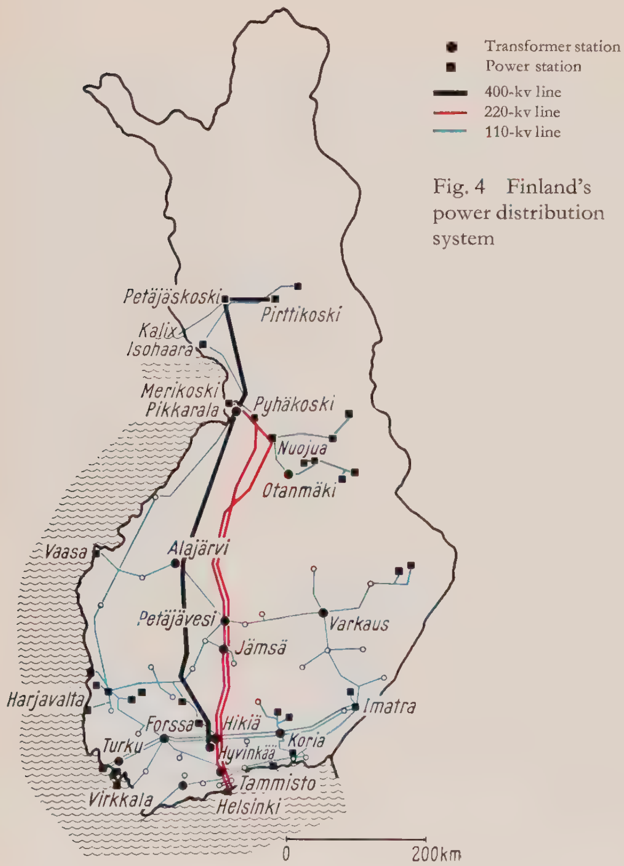


Fig. 4 Finland's power distribution system

MPST terminals for the 220-kv lines and SP terminals for the 400-kv lines of the Imatran Voima Oy (Finland)

The hydroelectric power stations on the Kemi and Oulu rivers in the north of Finland are among the largest in the country (Fig. 4). The seven power plants on the Oulu river alone supply about 30% of Finland's total power demand.

Since the majority of consumers are located in Central and Southern Finland, the power has to be transported to these points. This is accomplished chiefly over 220-kv and 400-kv powerlines.

One of the reasons which many years ago prompted the Imatran Voima Oy to equip some sections of the power network with automatic reclosing devices was the demand, placed in particular by the paper mills which are among the main consumers, for a virtually uninterrupted power supply.

The two 190-mile 220-kv sections Pyhäkoski–Petäjävesi and Nuojua–Petäjävesi have been equipped with protective relays which, through a blocking signal, insure simultaneous disconnection of the line at both ends whenever a fault develops. The signals are transmitted by SSB powerline carrier terminals.

Since telephone and teleprinter channels had to be established over the same line sections, MPST terminals with amplitude-modulated superimposed signaling channels operating in a 4-kc allocation plan were chosen. These systems have been in operation since 1953.

In the 400-kv sections, the carrier terminals had to satisfy two main requirements:

1. Signal transmission for protective relays.

2. Transmission of a remote switching signal following manual operation of a power switch.

For signal transmission on the Petäjäskoski–Pikkarala section, the Imatran Voima Oy uses FSK powerline carrier terminals which were first put through a stringent test. Among other things the level of the carrier signals received in Pikkarala (Fig. 5) was for this purpose reduced by about a further 3 nepers (26 db). Despite this, interference pulses produced by the repeated operation of disconnect switches did not give rise to false tripping. On the strength of these test results the same type of equipment was also ordered for the remaining 400-kv lines, the longest of which spans a distance of 310 miles.

In connection with the transmission of remote switching signals it should be stated that some sections of the 400-kv line are fed from both sides. In view of the great length of the line, this means that disconnection must likewise take place at both ends simultaneously when a switch is operated manually, because the voltage on the line not connected to load might otherwise rise to a level where arcing is liable to occur. The powerline carrier terminals are therefore supplemented by remote tripping attachments which encode the signal at the sending end and interpret it at the receiving end. This prevents the simulation of a signal by interference pulses on the powerline and is necessary because the tripping signal acts directly upon the tripping circuit of the power switch without previous interpretation by the protective relays. FSK powerline carrier terminals have been in operation in the network of the Imatran Voima Oy since 1958.

Fig. 5 Carrier coupling at the 400-kv Pikkarala station of the Imatran Voima Oy (Finland)

MPAT equipment in Abánico district in service of Empresa Nacional de Electricidad S. A. (Endesa, Chile)

Owing to the geographical location of Chile, a country extending for some 2,500 miles from north to south while ranging between only 30 to 150 miles in width, the interconnected power system has almost exclusively the form of a tandem network. In principle this network is a bus bar running between north and south and fed primarily by the hydroelectric power stations in the cordillera. In its final development stage the Abánico hydroelectric power station about 280 miles south of Santiago will feed some 140 Mw over two systems of a 154-kv line into the north-south bus at Charrua. The Concepción reactive power station is likewise connected with Charrua over a 43-mile 154-kv line.

To insure the necessary network stability under these conditions, line protection equipment operating with the fastest possible reaction had to be employed. This high-speed reaction has been realized with protection relays requiring a blocking signal with a delay time not exceeding 10 msec.

There were also requirements for fully-automatic duplex telephone circuits between the Abánico hydroelectric power station, the Charrua transformer station and the Concepción reactive power station. Six teleprinter channels were required for each direction for the teleprinter network.

To meet these requirements, not more than four carrier positions with a bandwidth of 4 kc each were to be allocated. In each band the range between 300 cps and 2,400 cps was assigned to telephony. Six teleprinter channels were superimposed in the region above this cutoff point. The two channels required for protective signal transmission thus had to be accommodated in the speechband. This solution was all the more necessary as each channel requires a bandwidth of 400 cps on account of the desired short delay time.

MPAT terminals for SSB transmission were therefore installed. The v-f attachments operate with FM. Since, in a blocking system, protective signals are transmitted only in an emergency, the speechband is used for signal transmission only for this short period. When the pro-

tective relays operate, the powerline carrier terminals at either end of the line are simultaneously switched from telephony to selective line protection. Through the selection of certain voice frequencies the protective signal channels are continuously supervised also during speech transmission.

A great many carrier terminals operating on this principle have been ordered for the 154-kv network; frequency-modulated MPAT carrier terminals have further been ordered for 60-kv sections of the network that operate under similar conditions.

Other installations

The examples quoted could be extended further, but this would go beyond the scope of this paper. One interesting detail, however, deserves to be mentioned: in Austria's interconnected network the 220-kv lines with solidly grounded neutral have to be disconnected immediately any fault develops because the communications equipment of the Austrian PTT would otherwise be exposed to hazardous touch voltages introduced through short-circuit currents by way of the buried communication cables.

Sweep-Frequency Measuring Setups for Time-Saving Measurements in the Range from 450 to 8,200 Mc

By Ludwig Frech and Josef Turban

Point-by-point measuring for, say, determining the frequency response of a measured quantity is not only a troublesome and time-consuming procedure but, if the frequency response curve is irregular, additional sources of error exist for values between the various points. In many cases the measured value cannot be attained without performing a number of trimming operations which are interactive and often difficult to keep track of. Such is the case, for instance, where the reflection coefficient of multi-tuned antenna filters has to be brought to its minimum value. The sweep method is both better and faster, the measured quantity here appearing – as the function of another value – as a continuous trace on the fluorescent screen of a CRT (Fig. 1). The value of the abscissa – such as the frequency of the measuring voltage – must vary automatically and recurrently in whichever frequency range is chosen (sweep oscillator).

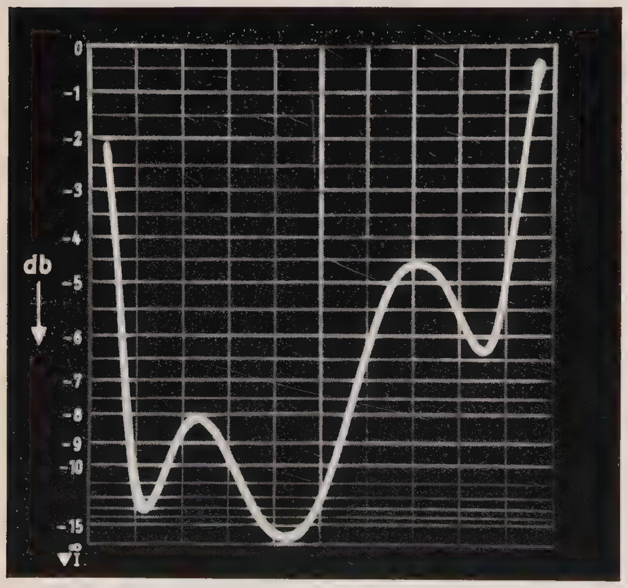


Fig. 1 Loss curve of an untrimmed bandpass filter

Tubes with a fluorescent screen display a stationary trace even at slow sweep rates. The sweep rate also depends on the sweep technique used; its maximum limit is determined by the transient behavior of the specimen and the frequency response of the measured quantity. In general, the light spot of the CRT is so controlled that its vertical deflection furnishes the measuring result, while its horizontal deflection represents, say, the frequency.

Attenuation and mismatch are important and have to be measured very frequently. As the essentials of the sweep technique are well illustrated by these two types of measurement, it is sufficient if we treat of these alone. Most of the equipment of sweep measuring setups can also be used to advantage for determining antenna gain and for many other applications as well.

The range from 450 to 8,200 mc is covered in the four subranges conventionally used in transmission engineering:

I	450 to 1,000 mc
II	1,600 to 2,800 mc
III	3,300 to 4,500 mc
IV	5,800 to 8,200 mc

In designing equipment for a line of such sweep measuring setups, it had to be taken into account that, for

various non-sweep operations, there is also a requirement for point-by-point measuring, that coaxial systems are predominant at the low end of the spectrum, and that coaxial and waveguide systems are used together at the high end of the spectrum. Finally, considerations of economy made it necessary to restrict the number of types of equipment to a minimum, this being particularly important in view of the large mechanical outlay for microwave equipment.

Each setup comprises three main groups of equipment:

a) A sweep oscillator that supplies a measuring voltage that changes its frequency continuously and in periodic sequence.
b) A measuring arrangement for evaluating reflection coefficient, attenuation, etc.
c) A visual display unit on which the measured values appear as a curve.

Accessories such as attenuators, lowpass filters and line terminations complement the regular equipment of the setup. In many cases a frequencymeter will be required for the injection of frequency markers.

The sweep oscillator is required to have a frequency sweep (sweep width) that can be varied within wide limits. Considerations of economy prompted the development of a power supply and modulating bay that can be used for all oscillators in common and also accommodates the plug-in sweep generators for the various frequency ranges. The generators are composed of coaxial resonators with tuning pistons and disk-seal triodes or reflex klystrons as a source of oscillation.

For sweep operation in narrow frequency bands such as are required for measuring filters, an electrodynamic system moves a small supplementary piston back and forth in the cavity resonator at the respective center frequency. The sweep width is adjustable through the amplitude of a 5-cps control voltage. Medium and large sweep widths are realized by displacing the tuning piston by means of an automatically reversing motor drive, the desired range of coverage being set by means of two pointers. The oscillator also supplies the sweep voltage (frequency axis) for the detector.

Measuring arrangements for reflection coefficient and attenuation. For the broad frequency range covered by our line of measuring setups, a combination of coaxial reflectometer bridges and coaxial and waveguide directional couplers (Fig. 2) has proved useful for the measurement of reflection coefficient and attenuation.

The main frequency range from 50 to 3,000 mc of coaxial systems is covered by two coaxial reflectometer bridges [1], i.e. the Rel 3 R 251 model for 50 to 1,000 mc and the Rel 3 R 252 model for 300 to 3,000 mc.

These consist in principle of four bridge arms – two large inductances of exactly equal value, a standard impedance Z_0, a terminal for the specimen Z_x – and two crystal diode arrangements for the measurement of input and output voltage. Given a constant input voltage, the voltage across the output of the bridge will be proportional to the reflection coefficient of the specimen Z_x. The natural error of the bridges is very small.

The directional coupler [2] permits the separate coverage of the incident or the reflected wave, depending on the direction in which the coupler is inserted in the r-f lead. It is thus suitable for determining both the reflection coefficient – the incident and reflected waves are measured by two individual couplers or a double coupler preceding the specimen – and the attenuation, for which purpose two respective couplers measure the incident wave preceding and succeeding the specimen.

On the coaxial sector, loop couplers are primarily used. Coaxial directional couplers Rel 3 R 255 and Rel 3 R 259 are available for measuring attenuation up to 40 db in the ranges from 450 to 1,000 mc and from 1,700 to 2,700 mc respectively. If a slightly greater error than that of reflectometer bridges is accepted, these coaxial directional couplers can also be used to determine the reflection coefficient. In the waveguide ranges, reflection coefficient

Front left:
Reflectometer bridge
300 to 3,000 mc, Rel 3 R 252

Front right:
Coaxial directional coupler
450 to 1,000 mc, Rel 3 R 255

At back:
Waveguide directional coupler 34 × 15,
5,800 to 8,200 mc, Rel 3 R 239

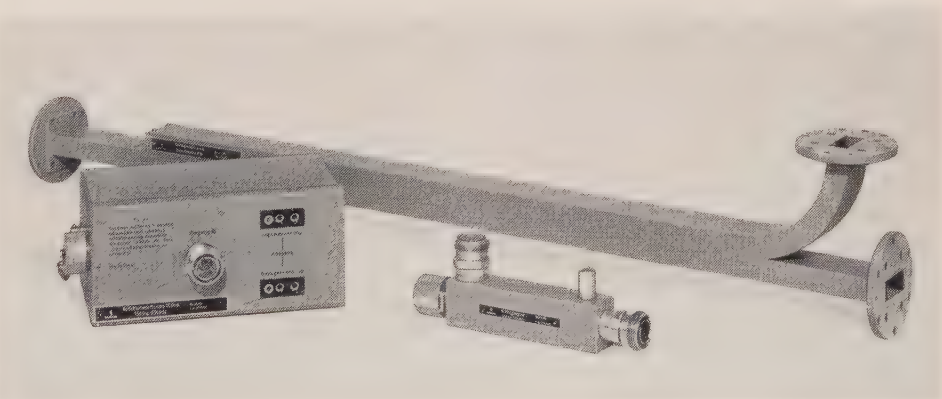


Fig. 2
Devices for measuring reflection coefficient and attenuation

and attenuation are measured exclusively with multi-hole waveguide couplers. The directional coupler Rel 3 R 241 with a waveguide cross section of 58 × 29 mm serves for the waveguide band from 3,300 to 4,900 mc, while the Rel 3 R 239 with a cross section of 34 × 15 mm is for the band from 5,800 to 8,200 mc.

Ratio tracing receiver. The quantities to be measured – reflection coefficient and attenuation – are defined as ratios. In the microwave technique, however, the voltage across the specimen can no longer be held stable over broad ranges by simple means. It is therefore advisable to equalize the effects of voltage fluctuations in the visual display unit.

The visual display unit Rel 3 K 217 is a ratio tracing receiver. Two voltages are applied to the receiver and the resulting ratio appears as a trace on its fluorescent screen. One of the voltages – the reference voltage – is proportional to the input voltage of the measuring circuit (e.g. incident wave), while the other – the signal voltage – is proportional to the measured value. Fluctuations of the measuring voltage up to 10 db are equalized by a regulating amplifier. Irrespective of what the r-f range of the measuring circuit may be, a 1-kc voltage (demodulated r-f voltage) always reaches the ratio tracing receiver.

The reference and signal voltages are obtained with the aid of broadband crystal diode probes. The crystal diodes must exhibit a well-defined, uniform characteristic throughout the entire amplitude range. As the available r-f power is not usually sufficient for operation in the linear portion of the characteristic – and in many cases

Frequency range	Measured quantity	Measuring range (full-scale deflection)*	Type code	Measuring circuit	Sweep oscillator	Indicating unit
450 to 1,000 mc	Reflection coefficient	0.01 to 1	Rel 33 K 72	Reflectometer bridge 50 to 1,000 mc Rel 3 R 251	450 to 1,000 mc Rel 3 W 76 in Rel 3 W 920	Ratio tracing receiver Rel 3 K 217
	Reflection coefficient Attenuation	0.02 to 1 40 db	Rel 33 K 76	Coaxial directional coupler 450 to 1,000 mc, 18 db coupling factor Rel 3 R 255		
1,600 to 2,800 mc	Reflection coefficient	0.01 to 1	Rel 33 K 73	Reflectometer bridge 300 to 3,000 mc Rel 3 R 252	1,600 to 2,800 mc Rel 3 W 77 in Rel 3 W 920	
1,700 to 2,700 mc	Reflection coefficient Attenuation	0.03 to 1 30 db	Rel 33 K 77	Coaxial directional couplers 1,700 to 2,700 mc, 18 db coupling factor Rel 3 R 259		
3,300 to 4,500 mc	Reflection coefficient Attenuation	0.01 to 1 40 db	Rel 33 K 78	Waveguide directional couplers 3,300 to 4,900 mc, 10 and 30 db coupling factor Rel 3 R 241 a, b	2,600 to 4,500 mc Rel 3 W 78 in Rel 3 W 920	
5,800 to 8,200 mc	Reflection coefficient Attenuation	0.01 to 1 40 db	Rel 33 K 79	Waveguide directional couplers 5,800 to 8,200 mc, 10 and 30 db coupling factor Rel 3 R 239 b, d	5,800 to 8,500 mc Rel 3 W 515 with Rel 3 W 913	

* Scale range plus 10 (15) db

Table 1 Survey of equipment for sweep measuring setups ($Z = 50$ and 60 ohms)

only low r-f voltages may be applied to the specimen – the square-law portion of the characteristic was chosen ($E_{AF} \sim E^2_{RF}$).

The measuring range is thus limited

a) at the top by the end of the square-law portion of the characteristic of the crystal diodes ($E_{RF} \approx 50\ mv_{rms}$);

b) at the bottom by the sharply (square law) decreasing rectified voltage and the limit of sensitivity of the tracing receiver.

The receiver has an r-f measuring range of 50 db extended over a scale range (logarithmic scale divisions) of 10 (15) db, and eight 5-db steps. Since $E_{AF} \sim E^2_{RF}$, the a-f measuring range of the receiver represents 100 db (corresponding to 1:100,000). Table 1 gives a survey of the various sweep measuring setups. The setups are suitable for investigations on two-terminal and four-terminal networks.

Reflection coefficient measurements

Fig. 3 shows the basic layout of a sweep measuring setup with directional couplers for reflection coefficient measurements.

The sweep oscillator supplies the r-f voltage for feeding the measuring arrangement, which consists of two directional couplers connected back-to-back and the specimen. This r-f voltage is on-off keyed with the frequency f_T (1 kc) and swept with f_W (5 cps). The directional coupler I determines the amplitude of the incident wave and, following demodulation in probe I, applies it as a reference voltage (AF) to the tracing receiver. The directional coupler II measures the voltage reflected in correspondence with the reflection coefficient r of the specimen, while probe II rectifies it and passes it on as a signal voltage.

In the tracing receiver the reference voltage is translated by heterodyning with the frequency f_M (19 kc) and the upper sideband $f_M + f_T$ (20 kc) applied to the regulating amplifier together with the signal voltage. Behind this amplifier the reference voltage (20 kc) is regained through a highpass filter, rectified and compared with a constant standard voltage. The deviation from standard serves as a regulating criterion. When the reference voltage rises or drops by a factor a, the gain of the signal voltage varies by the same factor. After regulation, the signal voltage is thus independent of any fluctuations of the oscillator voltage and, after amplification and rectification, directly yields the measuring result.

Fig. 4 shows the Rel 33 K 72 reflectometer sweep measuring setup for 450 to 1,000 mc with measuring bridge (high accuracy).

Depending on the frequency range of the specimen, the sweep oscillator can be operated with a 5-cps sweep in a continuously variable range up to 12 mc, or with a broad sweep in a continuously variable sweep range of about 8 to 550 mc, in the frequency range from 450 to 1,000 mc.

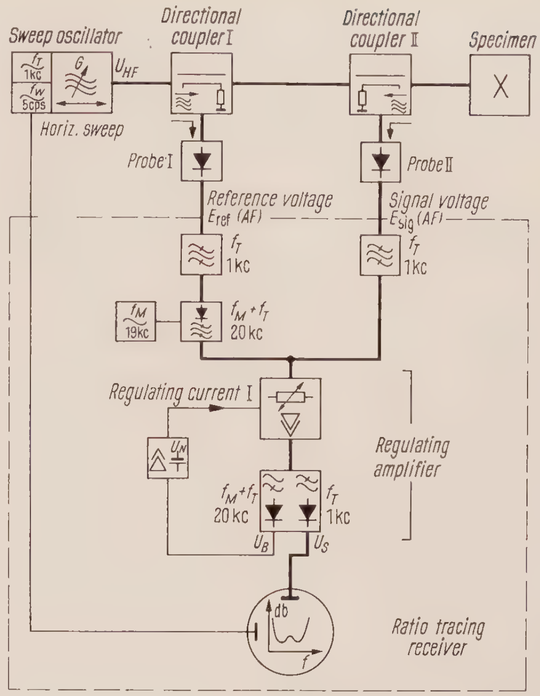


Fig. 3 Block diagram of a reflectometer sweep measuring setup with directional couplers and functional diagram of ratio tracing receiver Rel 3 K 217

A lowpass filter is interposed between oscillator and bridge for cutting out a 10-db pad and for filtering out harmonics. It is in many cases desirable to inject frequency markers into the trace. For this purpose the electron beam of the CRT of the tracing receiver can be gated out. The control voltage here used is drawn from a selective frequencymeter that is looped into the line by way of directional couplers.

The reference standard N (50 or 60 ohms) is already embodied in the bridge. The ratio of the bridge output (signal) voltage to the bridge input voltage (reference voltage) is decisive in measuring the reflection coefficient. Both voltages are supplied by the crystal diodes embodied in the bridge.

The measuring arrangement must be calibrated before the specimen is connected. For calibration, the bridge need only be operated without a load (open terminal) or with a short circuit (with shorting plug attached to equipment) – in correspondence with a reflection coefficient of r = unity. The light spot on the CRT should here advisably be set to 0 db $\triangleq r = 1$ by means of a calibration control. Calibration with a reflection standard, e.g. $r = 0.1$, however, is also possible. In view of the universal applicability of the equipment, the rangeswitch and screen graticule are marked in db. The ratio tracing receiver thus first traces the reflection ratio. An auxiliary scale resembling a slide rule is mounted on the rangeswitch to permit fast, effortless conversion into reflection coefficients.

On completion of calibration to 0 db, the specimen may be connected. Let the measured value read be assumed to be, say:

$$\text{Reflection ratio} = 26\text{ db} \triangleq \text{coefficient } 20$$
$$= \text{reflection coefficient } r = 0.05$$

The measured value appears as a vertical trace on the CRT. The voltage for the horizontal sweep (frequency axis) is supplied by the sweep oscillator.

a) For the 5-cps narrow sweep, the sweep voltage (5 cps) of the oscillator effectuates control action direct;

b) For a broad motor-driven sweep, the tracing receiver is controlled by a 30-kc voltage that is amplitude-modulated by way of a follower potentiometer;

c) For general applications, a supplementary sweep feature is provided through which a constant d-c voltage is supplied by the tracing receiver to the follower potentiometer of a sweep device and the fractional voltage picked off by the wiper serves for the horizontal sweep.

It should further be stated that, irrespective of whether the sweep width is large or small, the trace can always be adjusted to full screen width by way of an appropriate sweep amplifier.

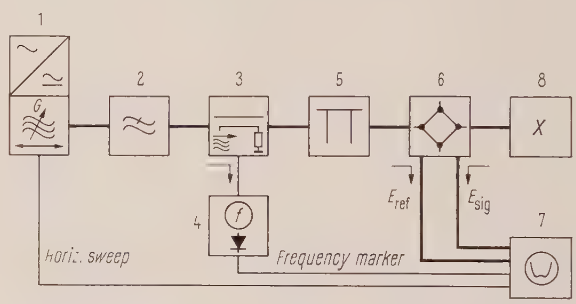
Attenuation measurements with directional couplers

The layout of the measuring setup (Fig. 5) is similar in principle to that of the arrangements already described. Here, too, a frequencymeter is provided for the injection of frequency markers permitting exact measurements during sweep operation. For attenuation measurements the directional couplers are circuited so that one determines the incident wave preceding and the other the incident wave succeeding the specimen. The measurement is thus free of error despite periodic voltage fluctuations in the case of mismatch (superposition of incident and reflected wave).

Guidance for operation

Indicating time constants: The tracing receiver can be set to various indicating time constants. As a basic rule, the smallest time constant (0.3 msec) should be chosen for narrow-sweep operation because all the fine details (pips) of the trace then show up clearest. In practice, a choice may be made among the settings 0.3, 1, 5 and 50 msec according to which secures the best trace with respect to curve irregularities (steep edges) and sensitivity (noise). As already explained, exacting requirements are imposed on the tracing receiver with respect to sensitiv-

1 Power supply and modulating case Rel 3 W 920 with sweep oscillator chassis 450 to 1,000 mc, Rel 3 W 76
2 Coaxial lowpass filter 680 to 1000 mc, Rel 3 F 67 d
3 Coaxial directional coupler 450 to 1000 mc, Rel 3 R 255
4 Frequencymeter 450 to 1,000 mc, Rel 3 F 142
5 Coaxial pad 10 db 0 to 5,000 mc, Rel 3 B 372
6 Reflectometer bridge 50 to 1,000 mc, Rel 3 R 251
7 Ratio tracing receiver Rel 3 K 217
8 Antenna filter (specimen)



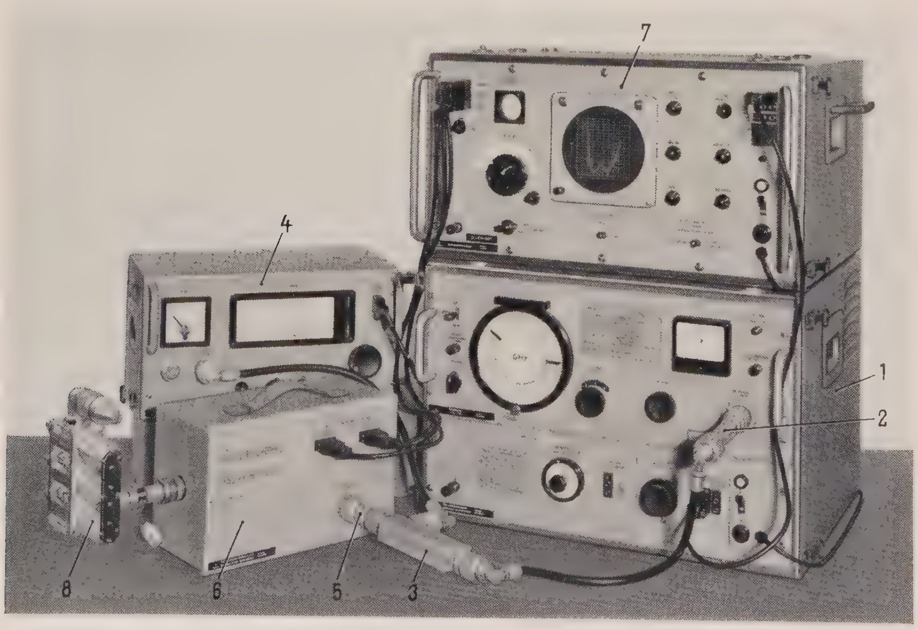


Fig. 4 Rel 33 K 72 reflectometer sweep measuring setup, 450 to 1,000 mc, for trimming antenna filters for FM 12/800 radio relay system. Block diagram is seen above

ity as a result of operation in the square-law portion of the characteristic of the crystal diodes.

Coupling factor: Assuming operation in the square-law portion of the crystal diode characteristic, the on-off keying ratio of the oscillator, equalization of the effects of voltage fluctuations of the oscillator, etc., an r-f signal voltage measuring range of 20 db (corresponding to 40 db at the a-f end) results. This can be extended by another 20 db, as with the ratio tracing receiver Rel 3 K 217, by switching the reference voltage. It is therefore not advisable to use two directional couplers with the same coupling factor. Thus the directional coupler for the incident wave has a coupling factor that is 20 db higher than that of the coupler for the reflected wave.

Range of regulation: Fluctuations of the reference voltage (voltage across specimen) are equalized in the ratio tracing receiver. The range of regulation is 10 db (r-f fluctuation); the maximum regulating error liable to be encountered is 0.3 db. To prevent the admissible range of regulation from being exceeded during operation, an inertialess CRT with two independent fluorescent strips has been incorporated. The strips show whether the oscillator voltage lies within the range of regulation and whether it is too high or too low.

Recorder terminal and camera attachment: It is frequently required for traces to be permanently recorded. For this purpose a recorder can be connected (tracing receiver has two separate terminals for d-c and a-c voltage operation) or a camera attached (a suitable bracket is mounted in front of the screen of the CRT).

Other applications

As shown by the following examples, sweep measuring setups can be used to advantage for other applications besides measuring reflection coefficient and attenuation:

Measurements on antennas. Besides the reflection coefficient, another important characteristic of an antenna is its gain – defined as the power ratio of the specimen to a standard antenna (folded dipole) as a function of frequency. It is thus necessary to intercompare two powers and so determine the ratio. The sweep measuring setups with a ratio tracing receiver are well suited for such investigations (Fig. 6). The frequency range of the Rel 33 K 72 measuring setup covers the uhf-tv bands (470 to 790 mc). The signal for the horizontal sweep is transmitted by the oscillator to the receiver, which units are in this case located about 100 m apart, over a cable or by radio.

The directional characteristic can also be traced by the ratio tracing receiver. The oscillator applies a voltage of constant frequency to a radiator in whose field the antenna to be measured is rotated. The voltage delivered by the antenna controls the vertical deflection in the ratio tracing receiver; the horizontal deflection corresponds to the angle of rotation. A reference antenna (standard antenna) gives the reference voltage.

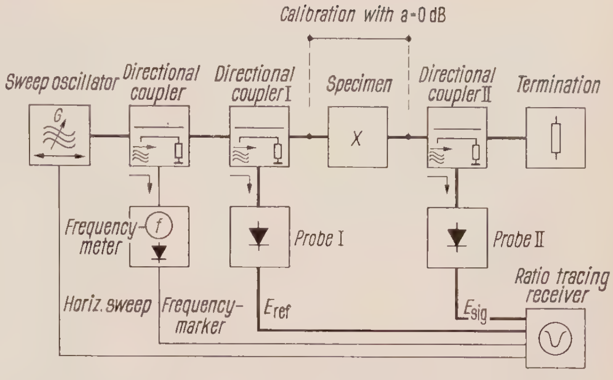


Fig. 5 Block diagram of a sweep measuring setup with directional couplers for determining attenuation

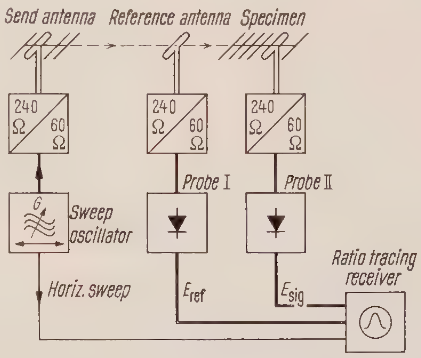


Fig. 6 Block diagram of a sweep measuring setup for determining antenna gain

Measuring and trimming of tv tuners. Tv tuners contain several circuits that have to be ganged so that the given passband curve is maintained throughout the entire band. Several setting elements are for this purpose provided for each circuit. A rational method of trimming such tuners is thus only possible with a sweep measuring setup.

The reference voltage for the ratio tracing receiver is derived at the r-f end with the aid of a directional coupler, while the signal voltage is derived at the i-f end with the aid of a probe such as the Rel 3 U 927. Significant frequency positions – center of i-f range, 3-db limit – can be accentuated by frequency markers. The oscillator operates with a 5-cps electronic sweep. The center frequency can be set to predetermined trimming frequencies either by way of a motor drive or by hand.

Measurements on specimens with limiter. If the specimen contains a limiter that already suppresses a portion of the voltage fluctuations of the oscillator, the ratio tracing receiver must not be fed a reference voltage from the measuring circuit because this would falsify the measuring result. A constant voltage should therefore be applied internally to the reference voltage amplifier. The gain of the signal arm is in this way maintained constant and the ratio tracing receiver acts as a level tracing receiver.

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Siemens Mülheimer Werk

By Adolf Knoop

The Mülheimer Werk, situated in the town of the same name in the Ruhr District, is engaged in the manufacture of steam turbines for high outputs and of gas turbines and turbo-generators. The works programme includes the complete equipment for turbo-sets with all associated auxiliaries, such as gears, steam condensers, pumping stations and seal-oil regenerating plant for hydrogen-cooled generators. A special product of the works is the Elmo* pump, a liquid-seal type of pump which is used as a vacuum pump or compressor in many fields of processing, and which can also be employed very economically for the evacuation of steam condensers.

In the course of time the works has been extended and modernized many times, particularly so in recent years. The workshops now cover an area of approx. 100,000 sq.m (120,000 sq.yds). The design offices, materials testing department, stores, administration offices and ancillary services are distributed over a large number of other buildings. Research and development are carried out in the works' own well-equipped laboratories which employ a competent staff of scientists, engineers, physicists, chemists, and mathematicians. At present the works have a total staff of 4,200 of whom 780 alone are engineers, technicians and foremen. Of the workshop staff 75% are skilled craftsmen.

The outstanding contribution made by the Mülheimer Werk to the general development of turbines and generators is reflected in some of its pioneering achievements. As early as 1929 the works constructed a 60-MW steam turbine for coupling to an 80-MVA generator. With a speed of 3,000 r.p.m., this turbo-set was for a long time the largest in the world and is still in operation today. The nineteen-thirties saw the introduction of many pioneering designs. These paved the way to high steam pressures and temperatures in which the works has become first and foremost, particularly since 1945. In 1951, for instance, the Mülheimer Werk manufactured the first turbine in the world for 600 °C and in 1955 the first turbine for a steam temperature of 650 °C. This was

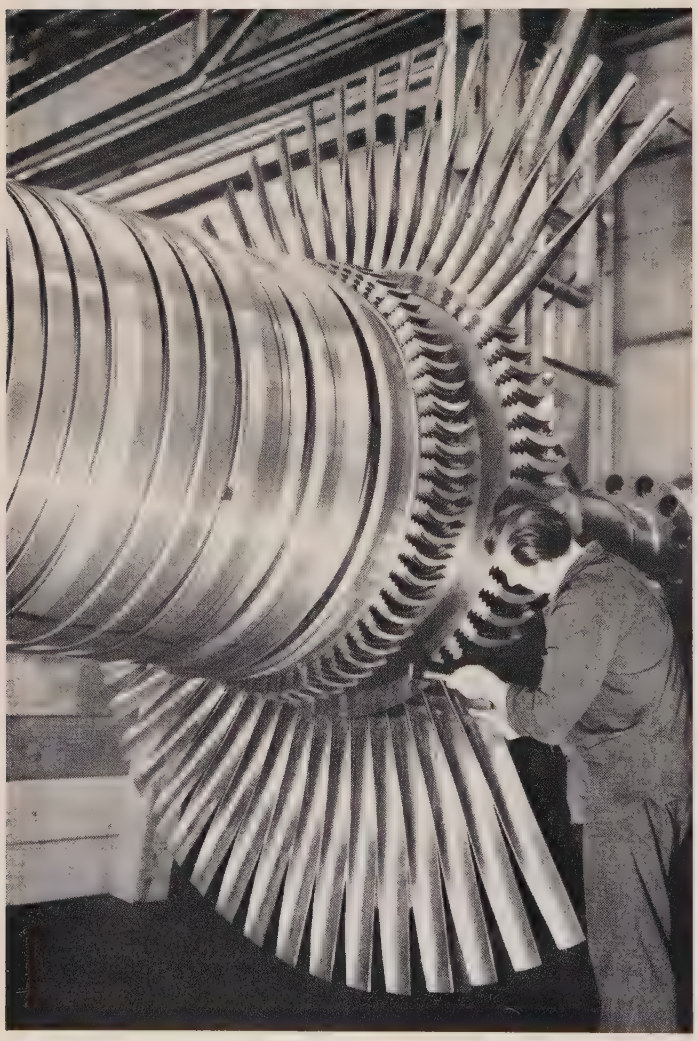

Fig. 1 Fitting the blades to a large double-flow low-pressure rotor. The 600 and 750 mm long blades of the last two rows are fitted to the rotor by means of fir-cone-shaped attachments. This method of fixing ensures that the blades are able to withstand the powerful centrifugal forces which at a speed of 3,000 r.p.m. exert a force of 47,000 kg (103,600 lbs) per blade in the last but one row and 82,000 kg (180,800 lbs) per blade in the last row

* Trade-mark

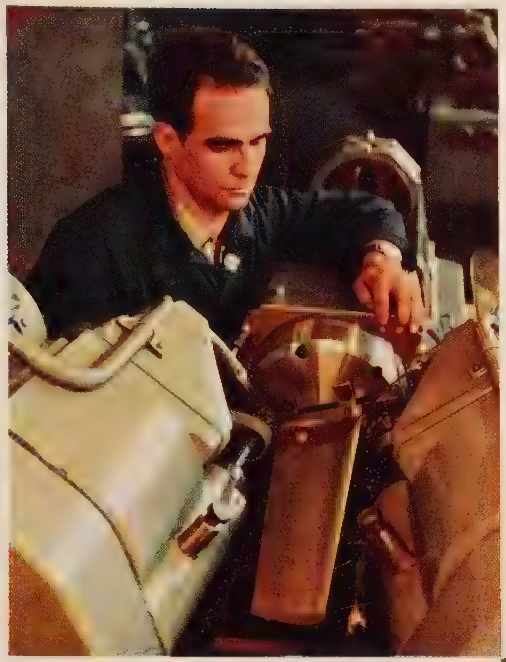

Fig. 2 Complicated blades for steam and gas turbines are manufactured on electro-hydraulically controlled milling machines which were developed by Siemens specially for the job and operate on the tracer copying principle. From a model, these machines can reproduce the profiles and blade lengths to any scale, larger or smaller, this being completed in one operation

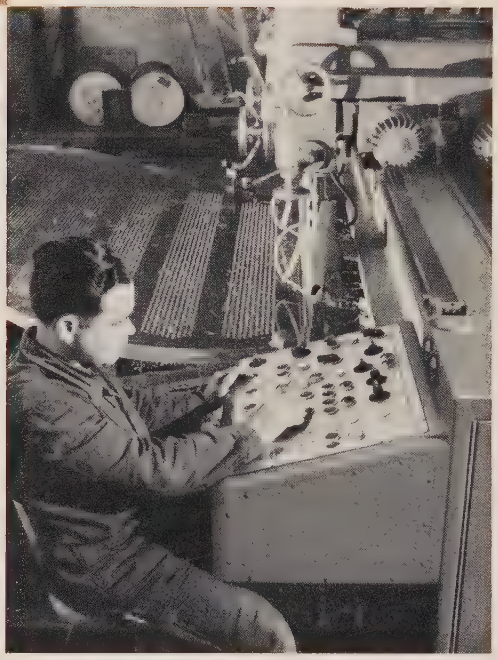

Fig. 3 Drilling the condenser tube sheets on a drill controlled by punched tapes – an example of rational production methods in the construction of large machines

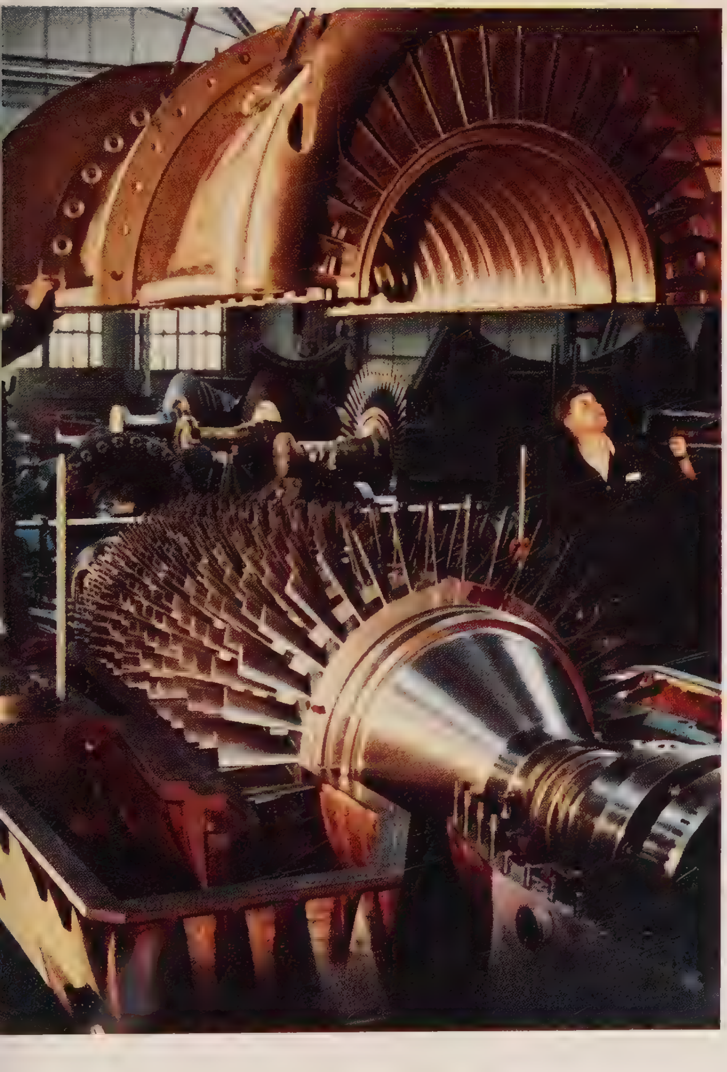

Fig. 4 Assembly in the test bay of a gas-turbine compressor for compressing 180 kg (396 lbs) of air per second to 6 kg/cm² (85 psia). The mechanical input is 43 MW

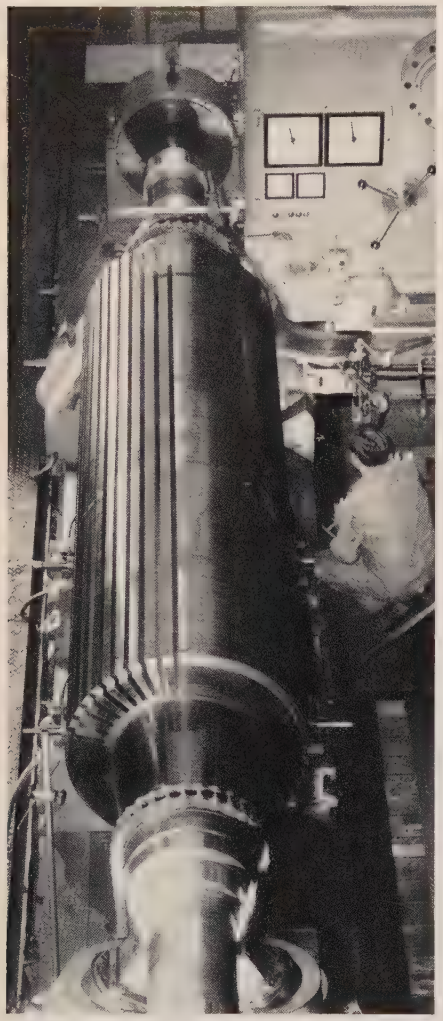

Fig. 5 Milling the winding slots in a generator rotor. The rotors are manufactured on a special production line. Pits are arranged in the immediate vicinity for balancing and overspeed tests. The largest can accommodate rotors weighing up to 130 tons

followed in 1956 by the supply of the first turbine in the world with a supercritical steam pressure of 330 kg/cm^2 (4,700 psig) and a steam temperature of 600 °C.

The development work carried out is directed not only to improvement of the useful heat drop but also to the construction of large low-pressure turbines with long end-row blades. Other items in the development programme include work on reheat turbines (single and double) and the intensifying of the generator cooling by methods in which the cooling media are applied directly to all electrically active components. The newly developed components are in accordance with latest engineering standards and make possible outputs which by far surpass all those obtained previously.

Gas turbines are at present being built for units with ratings between 1.5 and 22 MW. They are suitable for base-load or peak-load operation, for combined power and heat output and for all kinds of gaseous or liquid fuels.

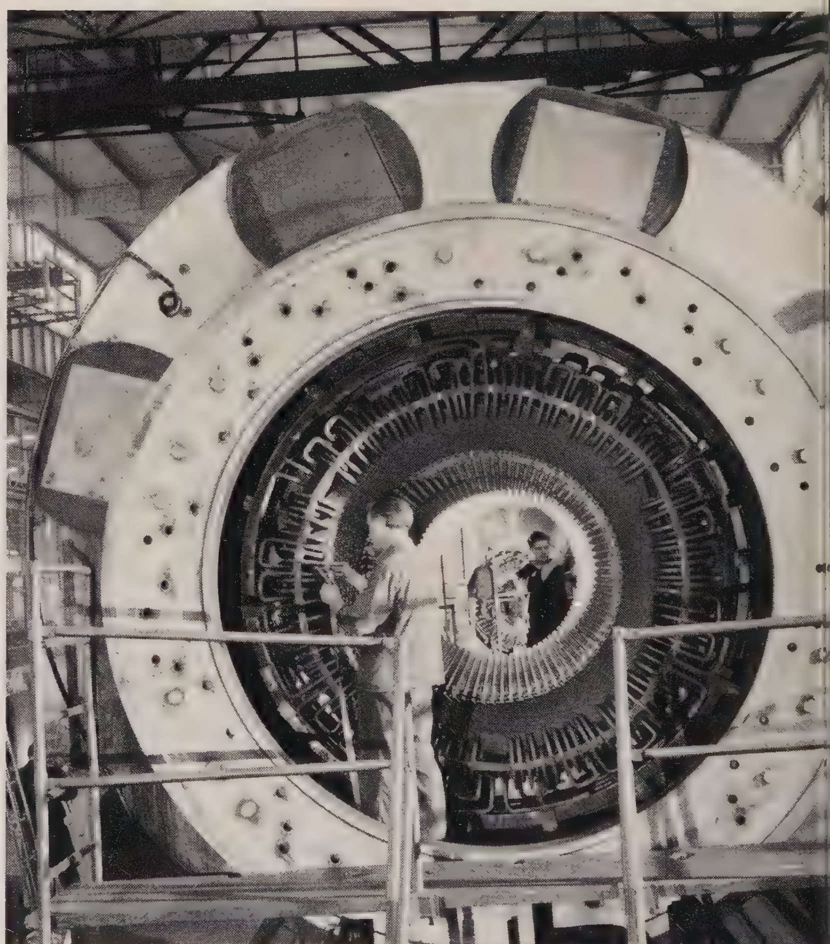

Fig. 6 Completing the winding work on the stator of a 200-MW generator. The stator winding has already been inserted. The end turns are carefully reinforced by insulating pieces and tape wrappings to enable them to withstand the powerful forces produced on the development of a terminal short circuit at full rated voltage

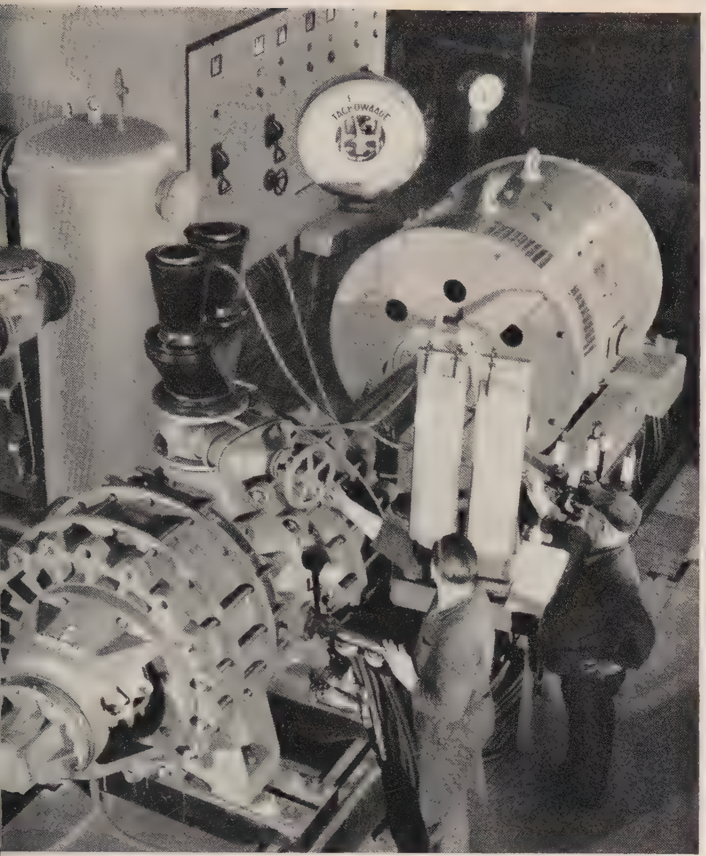

Fig. 7 Testing an Elmo carbon dioxide compressor with an intake capacity of 150 cu.m per minute (5,300 cu.ft per minute) at a pressure difference of 12 m (39 ft) w.g. This compressor is intended for a sugar mill, many of the parts being made of highly alloyed chrome-nickel steel. At present it is the largest liquid-seal pump of its kind

Fig. 8 This water tank for model flow tests is part of the experimental equipment used for determining the optimum blade profile. The experiments for determining the design of the individual blades are followed by further experiments on the flow characteristics of the blades when arranged in complete rows and stage groups

In 1958 the manufacture of industrial turbines was transferred to a new works in Wesel on the Rhine. This has made it possible for the Mülheimer Werk to concentrate on building even larger steam turbosets and gas turbines. Thus the manufacturing programme has been able to keep pace with the constantly increasing requirements for high capacity power plants.

Fig. 9 Heat-resistant steel is one of the most important materials used in the construction of steam and gas turbines. In special furnaces several hundred samples of materials are kept at temperatures between 400 and 800 °C over periods of up to 10 years. Checks are carried out constantly to determine creep characteristics, strength, elongation limits, structural change, embrittlement and resistance to the formation of scale

Automatic Rocking Supervision for Sugar Centrifuges

BY WALTHER KIRCHNER AND HEINRICH SELIGMANN

The automatic operation of a discontinuous sugar centrifuge[1] is divided into the following processes: Charging, centrifuging, correct application of the water and steam wash, ploughing and the automatic control of the motors which are generally of the pole-changing type. The entire cycle is thus completed without manual intervention of any description. Even faults are covered automatically by using the disturbance signal to shut down the plant and interrupt the cycle. In the case of automatic charging, i.e., charging not checked by the operating personnel, uneven entry of the massecuite can produce a degree of unbalance sufficient to cause excessive rocking of the basket shaft round the cardan joint, thereby damaging the basket due to its grazing against the casing. To prevent breakdowns with automatic centrifuge operation[2], it is therefore absolutely essential that a device be provided, which, on the development of excessive rocking, injects a disturbance signal into the control system.

Limit switches which were operated by mechanical contact with the shaft on excessive rocking did not prove to be very reliable owing to the fact that cold massecuite can easily cause them to stick, and that incrusted sugar on the shaft may give rise to inaccuracies in operation. Optical devices also had to be rejected owing to the effects of vapour and precipitation on the glass covers. The varying properties of the dielectric at different temperatures and degrees of humidity, and the difficulties associated with the provision of adequate insulation likewise obviated from the very beginning any solution of the problem by capacitive means.

The method most likely to succeed appeared to be one operating on the principle of variations in the inductance of an open iron choke core with a magnetic return path formed via the rocking shaft or the brake disc which rocks with the shaft.

Fig. 1 Coils for inductive supervision of the rocking of centrifuges. The coils are potted in synthetic resin

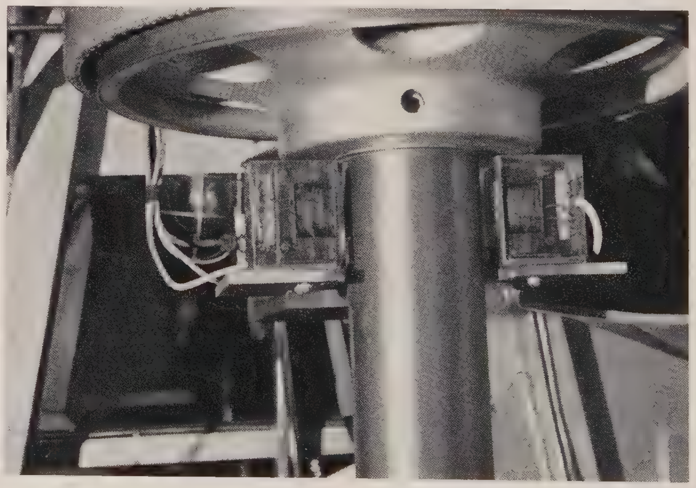

Fig. 2 Coils mounted on the shaft of a sugar centrifuge. The air gap between the poles of the induction coils and the shaft is 10 mm

1 Scherer, W.: Vollautomatisch arbeitende Zuckerzentrifugen. Zucker 13 (1960) pp. 278 to 281

2 Rojek, W.: Fully Automatic Sugar Centrifuges. Siemens Review XXVII (1960) pp. 181 to 184

The arrangement selected consists of a bridge circuit formed from two inductances. Two iron cores (Fig. 1), each with a double coil on the centre limb, are arranged at either side of the shaft (Fig. 2). Here, the clearance between the shaft and the end of the core is so selected that optimum effect is obtained without there being any danger of mechanical contact between the induction coils and the shaft at the maximum deflection.

The four coils are connected to form an a.c. bridge which is fed direct with a supply of 50 c/s. Following rectification and smoothing, the bridge voltage (galvanometer circuit) is passed to a transistor flip-flop circuit (Fig. 3). Via a transistor input amplifier stage, this controls a relay. The sensitivity of the entire device can be set by means of a variable resistor on the input side of the flip-flop stage. When the clearance between the iron cores and the centrifuge shaft is in each case 10 mm (0.39 in.), the response value for the deflection of the shaft can be set at between ±1 and ±6 mm.

The particularly arduous conditions under which centrifuge controls have to operate had to be taken into account in the design of the rocking supervisory device. Features include potting in Protolin* of the induction coils mounted on the shaft to provide protection against splashing of the mash and vapour. After the cable connections have been made on site, the terminals are also completely covered with this compound. On voltage fluctuations between –15% and +10%, such as can be expected in sugar mills, there was no noticeable change in the set sensitivity.

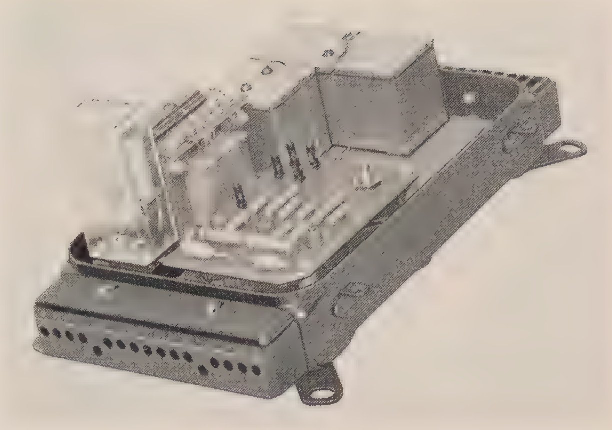

Fig. 3 Measuring device for the supervision of the rocking of sugar centrifuges. The flip-flop circuit is equipped with silicon transistors

In centrifuge stations, especially in sugar mills overseas, allowance must be made for high temperatures in the control cubicles. For this reason, the flip-flop stage and the amplifier have been equipped with silicon transistors. Checks carried out showed that the system operates perfectly satisfactorily at temperatures of up to 90 °C.

* Trade-mark

NEW EQUIPMENT

Shortwave Transmitters for Air Traffic Control

By Hans Süss

The growth of air traffic imposes increasing demands on the air traffic control network, which relies very greatly on the dependable functioning of ground-ground communication between airfields and ground-air communication between control towers and aircraft in flight.

Siemens & Halske have in this connection supplied two types of transmitter, together with appropriate antenna systems, for the Austrian air traffic control network's radio center near Vienna, which was placed in service a few months ago. The two types of transmitter are:

a 1-kw shortwave transmitter for ground–air communication
a 5-kw shortwave transmitter for ground–ground communication.

The illustration shows the radio center with its two types of transmitter.

Seen on the extreme left and extreme right is a 12-channel 1-kw shortwave transmitter. In most applications the transmitter serves for A 3 ground–air telephony (DSB telephony). As plate modulation is used, the full carrier power is available as the power output. The transmitter is also adapted for all other conventional classes-of-emission such as A 1 (c-w telegraphy), A 2 (modulated telegraphy), A 3a (SSB telegraphy) and F 1/F 6 (frequency-shift keying), and operates in the frequency range from 2 to 20 mc. As a result of the provision of two crystal oscillators, each of which can be equipped with twelve crystals, together with devices for the modulation and conversion of the information to be transmitted, two r-f channels are available simultaneously. To insure that two out of the twelve channels will always be ready for instant service, however, it is necessary that twelve power stages (final converter and power amplifier) should always be available for the twelve possible operating frequencies. Although this arrangement involves a certain amount of outlay for equipment, it guarantees the standard of readiness for service essential for air traffic control channels operating on different frequencies. It also permits control tower personnel to switch frequencies by remote control within less than 3 sec. The heat due to power dissipation in the power stages of the transmitters is carried off by twelve low-noise blowers and distributed throughout the room.

An antenna selecting bay permits any of the twelve power amplifier outputs to be switched to either of the two unbalanced transmitter outputs (60 ohms). A guard feature prevents any two power amplifiers from being switched simultaneously to the same antenna. The transmitter can be switched on and off and channels selected either directly at the transmitter or by remote control. The remote

control feature is at present equipped only for A1, A2, A3 and F1 classes-of-emission and can be set for the various channels at the transmitter. To initiate control and guarding action from remote control consoles, it is necessary to install a remote control center from where commands can be relayed to the transmitter. Indication lamps show which channels are in use in order to prevent wrong switching.

Radio center of Austrian air traffic control network

The second type of transmitter – the 5-kw shortwave transmitters (two bays on left and right of centrally placed antenna selecting bay) – serves for ground-ground communication. Each transmitter is composed of two bays and operates in the frequency range from 3 to 30 mc. It is equipped for A1, A2, A3, A3a, F1, F4 and F6 classes-of-emission. Its peak power is 5 kw. The information to be transmitted is fed to the transmitter in the form of telegraph signals or speech. The frequency range of a v-f band extends from 300 to 3,000 cps in the case of SSB operation (A3a) and from 100 to 6,000 cps in the case of DSB operation (A3). This telephone channel can, however, also be used for multiplex v-f telegraphy or facsimile transmission with v-f subcarrier.

The transmitter can be set with the aid of the VFO to any desired frequency within the overall r-f range (three subranges) in a matter of minutes. Inside the control unit, the oscillator with its six externally switched crystals of selectable frequency furnishes high netting and resetting accuracy even in the case of extremely fast frequency-changing. The heat generated in the power stages is removed by suction and compressed air.

Great value is attached in air traffic control to the transmission of weather maps. Facsimile transmission is possible with either F4 or F1 emission. In the case of F4 emission (facsimile) the picture signals to be emitted are fed as d-c pulses through the facsimile input directly to the F1 oscillator, whose frequency is modulated with a linear frequency swing of 0 to ± 400 cps. Shade values between black and white can be transmitted by this method.

If shade values are sacrificed, pure black and white values can be emitted with F1 operation at telegraph speeds up to 3,200 bauds.

The outputs of the two transmitters are unbalanced and dimensioned for cable with a characteristic impedance of 60 ohms. The antennas required for any given application can be rapidly selected with the aid of the antenna selecting bay (seen in center of illustration), which is designed on the crossnet principle.

Cables for Rural Low-voltage Systems

By Karl Bock

Today it is taken for granted that power supply systems in cities will be constructed with cables. No one disputes the fact that cable systems are much less susceptible to faults than an overhead-line system and that as a result of this maintenance costs are appreciably lower and outage times shorter. Following the expelling of all doubts concerning the use of the aluminium sheath as the neutral conductor, to which the problems associated with installation and connection originally gave rise, advantage is now taken in many instances of the reduction in costs afforded by aluminium-sheathed cables.

It would likewise appear to be a matter of course that rural low-voltage systems and cross-country lines should be of the overhead type. The view that cables are not economical for cross-country runs is justified no longer since new cable designs, aluminium-sheathed cables in particular, have brought about a noticeable reduction in costs [1]. The same operational advantages are afforded as in the case of urban systems. One might even say that there are more reasons for using them in the country, since the supervision of widespread cross-country lines, if they are not to be neglected, costs more than that for urban systems. If calculated properly, it will be seen that there is a genuine saving in costs, in addition to operational and other advantages. Decisive for the economy are not the first costs but the fixed annual costs for service of capital and maintenance charges [2].

Technical advantages

It would be wrong to simply compare an overhead line with a cable of the same cross-section or to compare an overhead line having aluminium conductors with a cable having copper conductors, as is done occasionally, without taking into account the great operational superiority of such a cable. The transmission capacity of a cable is 30% to 60% higher than that of an overhead line with its higher inductance. Thus, in a 380/220-V three-phase system operating at a power factor of 0.8, a cable with aluminium conductors having a cross-section of 70 mm² (0.108 sq.in.) can transmit a load moment of 8,550 kW-m if a voltage drop of 3% is not to be exceeded. An overhead line with aluminium conductors of the same cross-section is, however, only capable of carrying a load moment of 6,400 kW-m (Fig. 1). Over a distance of 500 m, the overhead line can thus transmit 12.8 kW, while the cable can transmit 17.1 kW, i.e., 33% more. In the case of cables having copper conductors the ratio is as much as 16.8 : 26.7 which corresponds to a 59% higher transmission capacity. In many cases, it is possible to install a cable of smaller cross-section instead of an overhead line and yet achieve the same results.

The interconnection of lines in built-up areas is a simple matter with cable systems and is generally considered to be an advantage [3]. In an overhead-line system, this has to be dispensed with since it is not usually possible to accommodate the junction fuses, unless the junction points are run to distribution cabinets as in cable

systems. However, this method of construction so increases the costs of the overhead line systems that it can be justified only where it is for other reasons not possible to install a cable system, for instance on rocky ground, where it is difficult to find space in the road bed, etc.

In the case of remotely situated individual consumers, the above-mentioned advantage cannot be utilized since here long cross-country runs are generally involved. The problem of the connection of individual consumers over long distances is one which arises frequently today, since in the course of field clearance on the land many farms have to be relocated, possibly to points several hundred yards away from the village and from the existing power supply system. Special attention has to be paid to the connecting up of these farms, since, in contrast to former times when agricultural consumers were considered to be an uneconomical proposition, the power consumption on farms is rising rapidly. Shortage of labour has made it essential that the electrification of farms, i.e., the introduction of electrically driven machinery, be accelerated. The higher standard of living on the land is accompanied by more stringent requirements with regard to the power supply. Television sets will sell particularly well in isolated rural districts, a fact which makes it imperative that close attention be paid to the maintenance of constant voltage.

First costs and annual costs

Since the technical advantages of a cable system have been clarified, consideration can now be given to the economical aspects. Neglecting for the moment the technical advantages, it will be seen that here, too, noticeable advantages are afforded. To show that cables are in each instance more economical than overhead lines, a comparison will be made of a cable and overhead line of the same cross-section on a straight run.

On a cross-country section, poles only will be used for an overhead line. For the case under consideration it is assumed that 50-m spans and wooden poles with insulators on swan-neck pins are employed. The system is a four-wire three-phase one with the neutral conductor having the same cross-section as the phase conductors. If the comparison is based on a section 1 km long, the costs of a cable with 4 × 50 mm² aluminium conductors, including the sealing ends, earthing material and connecting-up work, but excluding earthwork, have a ratio of about 90 : 100 to those for an overhead line with 4 × 50 mm² aluminium conductors, including protective gear, earthing and erection [1]. Thus the first costs of a cable system are lower than those for the overhead line if no account is taken of the earthwork. In country districts it will, of course, be cheaper to dig a cable trench than in a town with hard-surfaced and expensive roads. If the costs of digging work, laying the cable, bedding it in sand, covering it with bricks (if this is at all necessary) and filling in the trench are taken as being 45% of the total cost of the cable installation, the cost of the cable system will be 30% higher than those for the overhead line.

This extra cost turns many power supply undertakings away from the selection of a cable. The example given is, however, an extreme case since there are many instances where the costs would be the same, particularly where copper conductors are used or where the overhead line has to take a roundabout route which would not be necessary with a cable. It is not, however, the first costs which are decisive for the economy, but the annual costs such as interest, amortization of the invested capital and maintenance charges. The life of a cable is appreciably longer than that of an overhead line; this is the first economical advantage of a cable. To continue with the example, it has been assumed for the calculation that the life of the overhead line is 30 years (a period which is not attained by all lines on wooden poles). The life of the cable is to be 50 years. The interest rate has been fixed at 5% and the amortization is to be completed by the end of the serviceability of the installation. The annual service of capital with these values is 6.5% for the overhead line and 7.12 % for the cable referred to the first costs of the overhead line (= 100%).

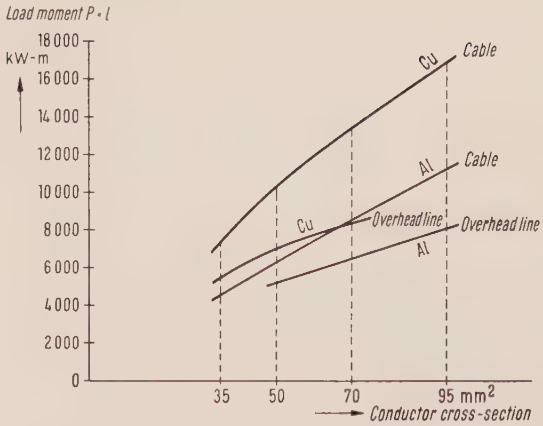

Fig. 1 Transmittible load moment for cables and overhead lines at $U = 380$ V, p.f. = 0.8, $\Delta U = 3\%$

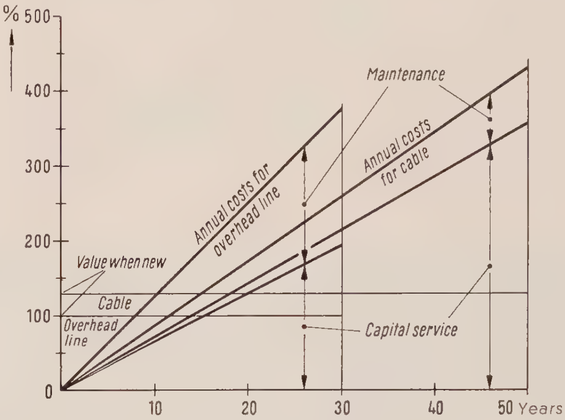

Fig. 2 Comparison of the annual costs for a cable and overhead line

No standard values can be given for maintenance costs. There is, however, no doubt about the fact that the maintenance and repair costs of overhead lines are three to four times as high as those of cables (second advantage of cables). For the example, the annual maintenance costs for the overhead line are assumed at 6% of the value of the plant, while the percentage for the cable is a fourth of this [4]. The costs for service of capital and maintenance of the overhead line over a period of 30 years are thus 375%. Within the same period of time, those for the cable are only 259%. At a life of 50 years, the value for the cable attains 431%. Fig 2 shows clearly the superiority of cables. The same annual costs are not attained until the first costs for the cable are twice as high as those for the costs of the overhead line.

In addition to the economical superiority of cable, account should be taken of the fact that the appreciably reduced maintenance requirements mean a saving in manhours. In view of the present-day shortage of labour, this point may in some cases even outweigh the financial advantage.

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MISCELLANEOUS

Port Lighting with Xenon Floodlights

By Werner Kipper

Some time ago, a fortnight's trial was carried out with a floodlight fitted with a 20-kW xenon high-pressure long-arc lamp in one of the 20 docks at Duisburg-Ruhrort. To achieve the same luminous flux as this unit, about 30 normal floodlights each with a 1,000-W incandescent lamp would be required. Such a comparison shows clearly the advantages of xenon lamps, particularly for the illumination of large areas. The Duisburg-Ruhrort dock mentioned is approximately 400 metres long and covers an area of over 10,000 square metres. The unit was mounted on a control tower 32 metres high located in the proximity of the dock.

One advantage of the xenon lamps is the fact that the spectrum of the light emitted by them closely approaches that of normal daylight. In the case in question, for instance, such a feature facilitates recognition of the signal and nationality flags of the ships.

With the xenon floodlights the light beam can be adjusted in the vertical plane by means of reflectors with highly polished anodized or matt diffusing surfaces. The maximum diffusion is ± 10 deg., with a constant horizontal wide-angle beam spread of ± 60 deg. It is therefore possible to provide uniform illumination of large areas from a minimum of points. The xenon floodlight is equally suited for illuminating harbour installations, large railway sidings, storage yards, building sites, sports grounds and, owing to the excellent colour reproduction, large market and exhibition halls.

The control gear is connected to the normal three-phase supply. A built-in high-frequency starter provides a momentary sparkover with a voltage of about 70,000 V for igniting the lamp. In order to preclude any danger to the operating personnel due to high voltages, a safety circuit prevents the lamp from being ignited as long as the unit is open. Xenon lamps are manufactured for outputs of 6, 10, 20 and 65 kW.

Illumination of a dock (left) by a 20-kW xenon floodlight mounted on top of a 32-metre control tower (right)

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SIEMENS **U.D.C.** 621.395.264

Herbert Töpfer and Konrad Rohde

Direct Inward Dialing to PABX Extensions — A Dial Office Problem?

5½ pages, 2 figures, 2 tables, bibliography

Siemens Review XXVIII (1961) pp. 217 to 222

Since the majority of public telephone calls originate and terminate in PABX's, in-dialing to PABX extensions will prove an important factor as dial telephone traffic grows. The paper treats of "free" and "fixed" numbering for PABX extensions adapted for in-dialing and its relation to the numbering plan of the dial office network. The question of rate registration is also considered. In conclusion, an account is given of experience gained with German PABX's adapted for in-dialing.

SIEMENS **U.D.C.** 621.316.718.083.722

Klaus Anke, Gerhart Kessler and Helmut Müller

Digital Speed Control

3½ pages, 4 figures, bibliography

Siemens Review XXVIII (1961) pp. 222 to 225

In order to increase the accuracy of speed control, analogue controllers (electronic tube, transistor, transductor) have been combined with digital controllers. While the former counter-act fluctuations of short duration, the latter correct deviations from the reference value occurring over a long period of time. The impulse frequencies are compared digitally by electronic counters; deviations are injected into the analogue circuit for correction. Within a speed range of 1 : 10, the digital controller operates with an accuracy of 0.1 to 0.01%.

SIEMENS **U.D.C.** 621.316.79.083.722

Klaus Anke, Karl Ertel and Gerhard Sinn

Digital Position Control

5½ pages, 11 figures, bibliography

Siemens Review XXVIII (1961) pp. 226 to 231

The work in the field of position control (follow-up control etc.) is today distinguished by very stringent accuracy requirements with limits as fine as one in a hundred thousand. The selection of suitable digital control systems, with which the reference and actual values are not represented by voltages, currents, temperatures, etc. but by numbers, together with the good dynamic characteristics inherent in analogue control, make it possible to meet these requirements. The digital distance control system is illustrated by way of an example of roll adjustment on a reversing mill.

SIEMENS **U.D.C.** 621.398:621.316:621.316.925

Reinhard Bartsch and Gerhard Bergmann

Transmission of Line Protection Signals over Powerline Carrier Circuits

5 pages, 5 figures, 1 table

Siemens Review XXVIII (1961) pp. 231 to 236

A description of the operating principle of selective protection systems is followed by an explanation of instances where carrier equipment can be used to advantage. The principal features of such equipment are described. A distinction is made between single-purpose and multi-purpose equipment, which latter may be designed for simultaneous or individual operation. To illustrate how to choose the most suitable type of equipment for a given instance, explanations are furnished as to why this or that type of equipment was chosen in practice. The systems described are those that have been supplied to Argentina, Chile and Finland.

SIEMENS **U.D.C.** 621.317.74

Ludwig Frech and Josef Turban

Sweep-Frequency Measuring Setups for Time-Saving Measurements in the Range from 450 to 8,200 Mc

5½ pages, 6 figures, 1 table, bibliography

Siemens Review XXVIII (1961) pp. 236 to 241

Increasing recourse is being taken to sweep techniques with a view to rationalizing microwave measurements. Four sweep-frequency measuring setups for the range from 450 to 8,200 mc are described. The setups serve primarily for plotting reflection coefficient and attenuation as a function of frequency, but are also suitable for determining the gain and directional characteristic of antennas, and for other applications besides.

SIEMENS **U.D.C.** 664.1.055:621.3.018.6.004.5

Walther Kirchner and Heinrich Seligmann

Automatic Rocking Supervision for Sugar Centrifuges

1½ pages, 3 figures

Siemens Review XXVIII (1961) pp. 246 and 247

For the fully automatic operation of sugar centrifuges it is essential that supervision be provided to prevent excessive rocking during charging and centrifuging. In the article the various possible methods of achieving this are subjected to critical examination. A system which has proved itself is one operating on the principle of induction whereby coils are arranged on open iron cores to form an a.c. bridge; the galvanometer circuit includes a transistor flip-flop stage.

SIEMENS **U.D.C.** 621.396.61:656.7.05

Hans Süss

Shortwave Transmitters for Air Traffic Control

1 page, 1 figure

Siemens Review XXVIII (1961) pp. 247 and 248

Shortwave transmitters are used for long-range links in air traffic control networks.

An account is given of a 1-kw shortwave transmitter for ground-air communication and a 5-kw shortwave transmitter for ground–ground communication.

Twelve r-f channels of the 1-kw transmitter are preset with respect to operating frequency and class of operation and permit a change of frequency within less than 10 sec.

SIEMENS **U.D.C.** 621.315.23:621.316.1

Karl Bock

Cables for Rural Low-voltage Systems

1½ pages, 2 figures, bibliography

Siemens Review XXVIII (1961) pp. 248 and 249

Electrical power supply systems in cities and on estates are generally constructed with cables. In rural districts, however, they still consist mainly of overhead lines. The introduction of new low-priced cables has now made it an economical proposition to use cables for the low-voltage systems in small towns and villages and even for cross-country runs to individual consumers. In making a comparison of the costs consideration must be given to the annual costs as well as to first costs. The fact that the life of cables is longer and the maintenance requirements very limited frequently makes them cheaper than overhead lines, even though the first costs are higher.

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SIEMENS U.D.C. 628.971.8:627.236

WERNER KIPPER

Port Lighting with Xenon Floodlights

½ page, 1 figure

Siemens Review XXVIII (1961) p. 250

Floodlights fitted with high-pressure xenon long-arc lamps are suitable for the illumination of large areas such as port installations etc.

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